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MISCIBLE OIL VERSUS FISH OIL SOAP SPRAYS FOR THE CONTROL OF FLORIDA ALEYRODIDS[1]

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Since the Division of Tropical and Subtropical Insect Investigations began its study of the Aleyrodid pests of *Citrus* in Florida in 1906, spraying experiments have been carried on more or less continuously, although for the first three years they were made secondary to problems associated with the biology of the pests (1) and their control by natural agencies (2) and fumigation (3, 4). Yet, in spite of the disconnected character of the work, a relatively large amount of data were secured either by, or under the direction of, Dr. A. W. Morrill, who was, until August, 1909, in field charge at Orlando. The work during this period definitely determined the relative value of the various home-made and the proprietary spray materials then on the market and gave data which proved beyond question the superiority of certain miscible oil sprays and standard brands of fish oil soap (5). The miscible oils tested, however, were rather expensive and, being of a proprietary nature, could not be recommended unreservedly. The development, therefore, during the past few years, by Mr. W. W. Yothers of the Bureau, of home-made miscible oil sprays, that are cheap, dependable and easily made, has been of great practical value to the citrus industry, and the enthusiasm with which his various formulæ and his spraying schedule for the control of Aleyrodid, rust mite and scale insect pests have been accepted by the leading citrus growers of Florida is evidenced by the rising vote of thanks given Mr. Yothers by the members of the Florida Horticultural Society at their 1915 meeting held at Tampa.

[1] Published with the permission of the Secretary of Agriculture.

Data proving the effectiveness of these home-made miscible oils have already been published by Messrs. Yothers and Crossman (6 to 9) and have been corroborated, if corroboration were necessary, by the senior writer during February and March, 1912, when he had temporarily resumed field charge of the investigations, and was assisted by Messrs. Wooldridge, Strickland and Rutherford. The data secured at this time merely emphasized the dependableness of Mr. Yother's formulæ, and various modifications of them. Sprays containing from ½ per cent to 3 per cent oil were used without injury to foliage. It was rather surprising to find that sprays containing ½ per cent and ¼ per cent of oil, made according to Formula IV of Mr. Yothers (7) were very effective, and it seemed probable that strengths less than the 1 per cent of oil recommended might be used profitably, particularly during the summer. Thus on 55 leaves picked from trees sprayed on February 27 with ¼ per cent oil and known to have been hit by the spray, 98.4 per cent of 5,040 pupæ were killed; while from two collections of leaves picked promiscuously from the trees which were sprayed at the same time and with the same strength of oil, 98.1 per cent of 1,972 pupæ found on 41 leaves and 98.7 per cent of 6,897 pupæ on 100 leaves were killed.

The purpose of this article is not so much to call attention to the effectiveness of home-made miscible oil sprays recommended by the Bureau, as it is to present certain data secured by the writers during the summer of 1910 which form a basis for comparison between these sprays and those made of fish oil soap. The results are based upon work with a proprietary miscible oil then on the market and a good fish oil soap. An analysis of the miscible oil made by the federal Bureau of Chemistry at the request of Mr. C. L. Marlatt, in charge of the Florida investigations, proved it to be practically the same as the home-made emulsions recommended later by Mr. Yothers. The analysis is as follows: specific gravity at 20° C., 0.9123; unsaponifiable oils (mineral oils), 63.24 per cent; fatty acids (from soap), 5.61 per cent; sodium oxid (Na_2O), 0.63 per cent; water and undetermined, 30.52 per cent; rosin oil not present.

So far as the writers are aware, no data have been published on the effect of summer showers upon the efficiency of insecticides in Florida. During the summer of 1910 a large amount of such data were secured which, in a greatly abridged form, is presented in Table I.

The complete data are on file. Each percentage recorded in Table I is an average of from three to seventeen similar averages, each in turn based upon an examination of over a thousand larvæ and pupæ. At least 210,000 larvæ and pupæ were examined.

The data indicate that the miscible oil sprays are scarcely affected

TABLE I.—EFFECT OF SUMMER SHOWERS UPON THE EFFECTIVENESS OF MISCIBLE OIL AND SOAP SPRAYS

Miscible Oil, Strength	Period of Time between Application of Spray and First Showers	Percentage of Larvæ and Pupæ Killed	Fish Oil Soap Strength	Period of Time between Application of Spray and First Showers	Percentage of Larvæ and Pupæ Killed
1½%	35 min. to 30 hours	98.2	16 lbs. to 50 gals. water	35 min. to 5 hours	90.2
	5 to 30 hours	98.6		5 to 10 hours	92.6
	30 to 34 hours	98.8		24 to 30 hours	96.2
	99 hours	99.3		99 hours	97.4
1¼%	1 min. to 5 hours	95.3	14 lbs. to 50 gals. water	1 min. to 5 hours	81.7
	5 to 34 hours	96.9		5 to 10 hours	82.5
	99 hours	99.5		27 to 32 hours	85.2
				99 hours	97.0
1%	35 min. to 5 hours	92.0	12 lbs. to 50 gals. water	35 min. to 5 hours	72.8
	5 to 10 hours	92.5		5 to 10 hours	73.7
	24 to 34 hours	93.2		27 to 32 hours	74.4
				99 hours	97.6
			8 lbs. to 50 gals. water	1 min. to 2 hours	68.6
				99 hours	96.2
			5 lbs. to 50 gals. water	2 hours	71.8
				99 hours	79.8[1]
				No rain (spring)	96.3[2]

[1] Larvæ in third and pupal stages, and therefore more resistant to this strength.
[2] Larvæ in first and second stages.

by showers, except when these fall almost immediately after application. Detailed data show that summer showers falling after the oil spray has once had an opportunity to dry on the foliage, have very little effect upon the efficiency of the spray. Since the leaves gathered for the examination of the Aleyrodids were picked promiscuously, one must be prepared for slight unexpected variations in the percentages of forms killed. The main point to be emphasized is the greater weakening effect showers have upon the different strengths of soap spray than upon those of the oil spray. Thus showers, falling about 30 minutes after the oil spray had been applied, had little effect upon the percentage of forms killed, while they had a very evident effect upon that killed by the soap spray. The weaker strengths of fish oil soap were much more influenced by showers than the weaker strengths of the oil spray.

Miscible oil sprays appear to have a second advantage over soap sprays in that aside from being more resistant to showers, they are operative over a longer period of time after application, even when

no showers fall. Foliage sprayed with miscible oils remained slightly oily both in appearance and to the touch for several weeks after the sprays had been applied. Fish oil soap leaves no such evidence that the trees had been sprayed. In experimental work on a large scale, it became quite evident that the miscible oil sprays used were giving better results than the soap sprays. An examination into the subject proved that the greater efficiency of the oil spray seemed not to be due to a higher percentage killed of the larvæ and pupæ on the leaves when the spray was applied at the proper strength, but to the effect these insecticides had upon unhatched eggs or the young larvæ hatching therefrom within ten days to two weeks after application. The data in Table II represent the condition of the white flies in adjoining rows of the same badly infested grove during the summer of 1910.

TABLE II.—REINFESTATION OF FOLIAGE FOLLOWING USE OF MISCIBLE OIL AND SOAP SPRAYS

Insecticide	Percentage of Larvæ and Pupæ Killed	Total Number of Larvæ and Pupæ Counted	Total number of Leaves Examined	Total Number of Leaves Counted to Determine Reinfestation	Average Number per Leaf of 1st and 2nd Instar Larvæ Hatching after Spraying
Miscible oil 1¼%	98.3	20389	170	170	0.9
Miscible oil 1⅛%	98.0	72270	995	995	1.4
Miscible oil 1%	95.7	28077	500	165	2.0
Miscible oil ¾%	92.5	21344	170	170	2.1
Fish oil soap:					
16 lbs. to 50 gals. water	92.8	27712	225	225	8.2
14 lbs. to 50 gals. water	84.5	74642	705	398	12.7
12 lbs. to 50 gals. water	74.5	36103	350	211	10.9
8 lbs. to 50 gals. water	71.7	8247	400	125	24.2

The examinations upon which the data of Table II are based, were made between two and three weeks after the application of the spray. At all times during the summer months adults of both *Dialeurodes citri* and *D. citrifolii* are more or less abundant and depositing eggs. At times of summer spraying there are comparatively few leaves on infested trees, especially those infested by *citri*, that do not bear unhatched eggs in varying numbers. Those in touch with the white fly problems appreciate the fact that no matter how effective an insecticide may be in killing larvæ and pupæ on the leaves at the time the spray is applied, if it does not either kill these unhatched eggs or is operative long enough to kill larvæ that subsequently hatch, much of the benefit of the spraying is counterbalanced by the reinfestation thus brought about. In one grove in which 95 per cent of the larvæ and pupæ were killed by fish oil soap, a sufficiently large number of larvæ hatched after the spray was applied to cause a blackening of the

foliage within a comparatively short time. In a second grove sprayed with the miscible oil mentioned above, an equally large number of insects were killed, but the grove remained clean, *i. e.*, free from sooty mold on the leaves and fruit, for a very much longer time. Two neighboring groves sprayed during late April when the Aleyrodids (*citri* and *citrifolii*) were mostly in the early larval stages, one with the miscible oil used at the strength of $1\frac{3}{4}$ per cent oil, and the other with fish oil soap, 5 and 8 pounds to 50 gallons of water, perhaps emphasizes the importance of the point in question more than any large scale work undertaken by the writers. Both groves were sprayed by the writers and Mr. W. W. Yothers with equal thoroughness and with the aid of a power outfit. Results secured about ten days after spraying showed that the fish oil soap at 5 pounds to 50 gallons had killed as many insects as the miscible oil, and it was regretted that fish oil soap had not been used on both groves on account of the saving in the cost of insecticide. However, the grove sprayed with fish oil soap began to blacken and by July required a second spraying and needed a third by October to keep the fruit free from sooty mould. On the other hand, the grove sprayed with the miscible oil remained clean throughout the summer and was blackening in October only in places.

It is unfortunate that the percentage of larvæ and pupæ killed by the oil and soap sprays, given in Table II, are not more alike as there may be those who will think the much larger average number per leaf of living first and second instar larvæ, found on the leaves two to three weeks after spraying, is the direct result of the comparatively small number of forms killed by the fish oil soap at the time of application. It is possible, and more than probable, that in any grove so heavily infested, even if practically all the forms had been killed by the sprays at time of application, a certain amount of reinfestation from without would occur as migrating adults are quite active and may begin ovipositing within a day after emergence. However, the rows of trees sprayed with both oil and soap sprays were equally subject to reinfestation. No examinations for the first and second instar living larvæ were made until two to three weeks after the spraying in order to give the insects in these instars when the spray was applied, and that escaped the action of the spray, an opportunity to develop into third instar larvæ. Studies of the biology of *citri* (1) have proved that during the summer months the egg stage averages 10–12 days; the first larval, 7.2 days; and the second larval, 5.4 days. The corresponding instars of *citrifolii* are a trifle longer. These facts make it certain that the first and second instar larvæ recorded as living are those which hatched from the eggs present on the foliage when it was sprayed, or from a relatively small number of eggs deposited after spraying.

It cannot be stated whether the oil spray killed a larger percentage of the eggs than the soap spray as the eggs themselves were not examined at the time of spraying, and the newly hatched larvæ which would naturally feel most the hold-over effect of the spray are quite apt to fall from the leaf if they succumb before they have settled to feed. As the spraying was done by the writers themselves with the aid of a power outfit, on the same days and after much experience in manipulating a spraying outfit, it is unlikely that the oil and soap sprays were applied with such differences of thoroughness as to account for the marked differences in effectiveness recorded in Table II. As each strength of insecticide used in the work of Table II is known to be effective from a killing standpoint if brought in contact with each insect and permitted to act unmolested by rains, with the exception of the weakest strength of fish oil soap when used against mature larvæ and pupæ, the writers are of the opinion that the differences in the general effectiyeness of the oil and soap sprays used were due partly to the weakening effect of showers, and, in the case of the miscible oil, to the hold-over effect of the insecticide upon the eggs or the larvæ hatching from eggs during at least a ten-day period after spraying.

Incomplete as are the data presented in this paper, they indicate an advantage that miscible oil sprays have over fish oil soap sprays which is of a most practical, though subtle, nature. When growers of *Citrus* appreciate that it is much more profitable, and not more expensive, to spray their groves when the average number of Aleyrodids per leaf is small, rather than large, as is now the custom, this advantage will be even more valuable in postponing future blackening of the trees and fruit by the sooty mould.

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HOW TO TEST FOR THE PRESENCE OF NICOTINE ON SPRAYED PLANTS

By V. I. SAFRO, *Louisville, Ky.*

It has been generally believed that as soon as a nicotine spray dries on the plant it disappears and that any results following the application of nicotine must necessarily occur immediately or very shortly after the application. This belief, however, has been rendered uncertain in the light of recent developments, several of which have appeared in print, regarding the effects of nicotine insecticides.

The writer conducted some tests last fall which showed definitely that nicotine may be present a considerable time after the spray has dried and apparently disappeared from the plant. This new finding tends to assist in explaining some of the hitherto unlooked for effects of the application of nicotine insecticides. Because of the widespread interest among entomologists and the many inquiries the writer has received as to the method of indicating the presence of nicotine upon sprayed plants, he believes it will be of interest to describe briefly the procedure, so that entomologists may be in position to conduct tests of this kind in the course of their own investigations.

THE TEST

Take a number of leaves that have been sprayed and which it is desired to test for nicotine, and thoroughly rinse them in a minimum amount of distilled water. Bark, twigs and fruit may be subjected to the same test as the leaves. The number of leaves or amount of material necessary to use in order to obtain a test depends on the amount of nicotine present. In some of our own tests where five leaves gave a doubtful reaction, ten leaves gave a definite one. Generally we were able to obtain a definite indication of the presence of nicotine in as little as 25 cc. of water by using five leaves that had been sprayed at the usual strength (about .05 of 1 per cent nicotine).

After having rinsed thoroughly, filter and make filtrate slightly acid with a few drops of hydrochloric acid. If a precipitate is formed at this point, filter again. To this filtrate add several drops of 1 per cent silicotungstic acid. A white cloudiness denotes the presence of nicotine. It will be found convenient to conduct this test in a glass beaker over a dark surface.

We have found that silicotungstic acid obtained from J. T. Baker Chemical Co., Phillipsburg, N. J., or from Merck & Co., New York City, satisfactory for this purpose.

After making up the 1 per cent aqueous solution, settle and filter. This solution will keep indefinitely.

Combinations

This test has been applied successfully to aqueous solutions of "free" nicotine, nicotine sulphate solutions, nicotine-soap solutions, nicotine-arsenate of lead, and nicotine-Bordeaux. It has not been found effective in testing nicotine-lime-sulphur, as the presence of colloidal sulphur derived from the polysulphides seems to interfere with the test.

Discussion

The boiling point of nicotine is 247° C. (447.8° Fahr.). This is particularly significant in view of the popular belief that nicotine evaporates much more rapidly than water and that when the spray has dried and is no longer visible on the plants, the nicotine has by that time also disappeared.

When nicotine solutions are used for fumigating greenhouses, there are generally two or three more or less distinct periods of boiling. When aqueous solutions of nicotine are used, there are two distinct periods, in which the water boils off first and later the nicotine. When alcoholic solutions are used, there are three more or less distinct periods of boiling: First alcohol, then water, then nicotine.

It is true that upon evaporation, under ordinary temperatures, concentrated solutions of nicotine become *stronger*. A sample of nicotine sulphate containing 40 per cent nicotine kept in a tumbler exposed at ordinary room temperatures for about three months showed at the end of that time a nicotine content of 49.46 per cent. A small sample of "free" nicotine left in a shallow dish at ordinary room temperature for two weeks increased in nicotine content from 40.71 per cent to 94.82 per cent.

In evaporation of dilute solutions under ordinary temperatures, probably the same general condition exists; namely, that the water evaporates much more rapidly than the nicotine, resulting in a continually increasing concentration of the nicotine film on the sprayed parts of the plant, until finally a very highly concentrated though invisible film of nicotine remains. The actual amount of nicotine left may be so small as to defy any attempt to determine it quantitatively and yet may show quite distinctly in the qualitative test.

How this film would work as an insecticide is as yet a matter of conjecture. The general opinion has been that the film may act as a stomach poison in being eaten by chewing insects. On the other hand, some believe the "odor" or fumigation would have some effect. All of these are possible, but it is also quite possible that this film is effective as a direct contact insecticide, on larvæ as well as other stages. As the film is very much more highly concentrated than the

original nicotine strength applied to the plant, it is quite likely that the mere contact of parts of the body of various insects with this film would be fatal.

In conducting this test whole leaves should be *rinsed* (preferably by dipping and stirring each leaf separately, holding on to the petiole meanwhile) without breaking the epidermis. Otherwise organic matter within the leaf, going into solution, may give a test similar to the nicotine test. As checks, the water being used in the experiment should be tested as well as the unsprayed leaves.

A CLERID LARVA PREDACEOUS ON CODLING MOTH LARVÆ

(SECOND NOTE)

By D. E. MERRILL, *State College, N. M.*

In the JOURNAL OF ECONOMIC ENTOMOLOGY, vol. VII, No. 2, April, 1914, on pages 251–252, appeared a first note on the clerid larva treated further below.

The larva in question was taken October 20, 1912. It was then nearly grown, judging by the sizes of later specimens. Below is its history as recorded:

October 20, 1912. Taken under a band on an apple tree. Placed in a glass jar with some bits of paper on some dry dirt. Given 6 codling moth larvæ.

October 17, 1913. Given 6 more codling moth larvæ.

June 18, 1914. Grown more hairy. Sluggish.

June 23, 1914. Fed 6 codling moth larvae.

July 8, 1914. All 6 larvæ put in last have transformed to moths. So the clerid ate none of these.

August 30, 1914. Transferred to a 4-inch covered Petri dish. Placed in dish some bits of paper and a "pupa stick" such as was used in the codling moth work at the Experiment Station for observing time of pupation. Given 8 codling moth larvæ.

September 7, 1914. Placed a second clerid larva in the dish. No. 1 very sluggish.

September 9, 1914. No. 1 was evidently starting to pupate when the second larva killed it and partially ate it, even when there were codling moth larvæ in the "stick."

In this period of nearly $22\frac{1}{2}$ months the larva had molted several times. Opportunity was not given to keep definite record of the molts of this or of later specimens. Only 26 codling moth larvæ were fed to the clerid larva in that time. Probably the first 12 were eaten. The 6 placed in the dish June 23, 1914, transformed to moths; 6 codling moth larvæ were found in the "stick" when the clerid died. Likely the two others of the last eight fed were eaten by the second clerid larva introduced on September 7, 1914. That leaves just 12 codling moth larvæ eaten in nearly two years.

The histories of 5 adults reared in the summer of 1915 are summarized below. The larvæ were all collected from codling moth bands on trunks of apple trees.

No. 1. This larva was the one mentioned as placed in the cage with the original larva on September 7, 1914. Pupation had taken place by May 30, 1915. An adult male clerid beetle emerged on June 14, 1915. In the approximate 9 months 17 codling moth larvæ were eaten.

No. 2. The larva of this specimen was taken with 8 others on December 30, 1913. All were about two-thirds grown. One adult female emerged June 14, 1915. One larva was alive, 7 had died in the 17½ months since the 9 were taken. In that time 29 codling moth larvæ had been fed to these larvæ.

No. 3. The nearly grown larva of this specimen was confined alone on March 15, 1915. It had pupated by May 29, 1915, and an adult female emerged June 14, 1915. In 3 months it ate 4 codling moth larvæ.

Nos. 4 and 5. Two large larvæ were taken Jan. 19, 1914. Four others of about the same size were placed with these June 23, 1914. Two emerging adults were taken June 14, 1915 and placed in alcohol before completely out. The sex was not recorded. The 4 other larvæ were dead and all but 1 partly devoured. In the 17 months 34 codling moths were eaten by the six. It can not be decided if the two adults were the two placed first in the cage.

The adult male and two adult females were placed in a cage together on June 14, 1915. On June 15 the male and one female were found in coitu. The female had chewed a hole in the thorax of the male injuring him so that he died the same day. This day the female ate 1 larva and 1 pupa of *Autographa sp.* Two days later she ate the same amount. On June 26 she was fed 2 larvæ of the *Autographa* and several codling moth larvæ. She did not eat well and died August 23, 1915, after being in a very sluggish condition for about six weeks. No eggs were found.

To Prof. H. F. Wickham, Iowa City, Iowa, the writer is kindly indebted for the specific determination of the adults and for numerous helpful notes and citations concerning certain clerids. The species was given by Professor Wickham as *Cymatodera æthiops* Wolcott, the citation to the description being given as "Field Museum of Natural History Publication 144, Zoöl. Series, vol. VII, No. 10, p. 350, May 1910." "The type was from El Paso, Texas. The cotype from Tucson, Arizona, both collected by me," Professor Wickham states. Further he says, "Cymatodera is usually beaten from partly dead branches and shrubs, or found hiding under loose bark."

The writer has taken adults at lights at State College, N. M. The specimens hatched out in the laboratory here, however, solved the question as to what species to refer the larvæ preying upon the codling moth larvæ. The term "warriors" applied to these predators by Mr. Stuart, an orchardist near Mesilla Park, N. M., is a very fitting common name.

No data are at hand as to the behavior of the adults in the feral state. That they are predaceous is demonstrated by the specimens in captivity. One clerid pupa was found in April, 1915, under a band and in a codling moth cocoon. In the laboratory the pupal cells were made by chewing up and cementing together bits of paper, or, in some cases, bits of the pasteboard partitions in the "pupa sticks" in which the cells were made. The cell was well walled in. The pupal case was merely a silvery film investing the developing beetle.

There is still a question as to the actual length of the larval period. The specimens experimented with above were all well grown when taken. Possibly the food supply was not as constant as it would be in nature. However, the larvæ were able to go without food for a long period, which would indicate an adaptation to an uncertain food supply. One nearly grown larva in confinement was fed well from March 15, 1915 to June 26, 1915. Then it was fed no more but did not die until Nov. 20, 1916,—a fast of nearly 17 months. Sharp, in Camb. Nat. Hist., Insects, Pt. II, p. 254, records "a larva (of *Trichodes ammios*) sent to M. Mayet refused such food as was offered to it for a period of 2½ years, and then accepted mutton and beef as food. After being fed for about a year and a half thereon, it died." Again, on the same page, "one of its larvæ (*Trichodes alvearius*), after being full grown, remained 22 months quiescent and then transformed to a pupa." Certainly a blessed quality to possess in lean years!

There is a question, too, as to the specific economic importance of *Cymatodera æthiops* in relation to the control of the codling moth. The members of the family Cleridæ are as a whole carnassial, but, evidently, widely so. In the feral state this species probably would not confine its attacks to the larvæ of the codling moth but would likely take whatever food chance offered to its liking. Where bands are kept on apple trees in winter the food supply is made more constant and the protection greater for the clerids. Better chance is given, also, for them to kill more of the codling moth larvæ. At the same time, from several years of observation, they do not appear to be ever sufficiently numerous to clean up the bands and underlying bark of hibernating codling moth larvæ. So the bands serve as places of protection to the latter, if not removed after the hibernation is begun. If removed, the clerids are destroyed with the codling moth larvæ. Probably they search out under the bark some few larvæ that would go unnoticed and in so doing help a little to reduce the number of spring moths emerging. However, they can not be relied upon to such an extent as to permit omission of removal and examination of bands in winter, where banding is practiced.

If the larvæ of this clerid were more numerous by having a more

rapid succession of generations, or if they had keener appetites and a special liking for the codling moth larvæ, the benefit from them would be more appreciable. With their long developmental period, small numbers, and their feeding scattered, both as to kind of larvæ, and as to generations of the codling moth larvæ, the appreciably effective control work done by this species is reduced to a minimum.

February 6, 1917.

HIBERNATION OF THE HOUSE-FLY IN MINNESOTA[1]

By C. W. HOWARD, *St. Paul, Minn.*

The manner in which the house-fly (*M. domestica*) survives the winter is a matter which has drawn considerable discussion in the last few years. The older theory, that it is the adult fly which passes the winter, for some time gave place to the theory that the winter was spent in the pupal and possibly in the larval stage. The recent work of Bishopp, Dove, and Parman (1915), and of Dove (1916) shows conclusively that in a mild climate such as that of Texas it is possible for both larvæ and pupæ to pass the winter and adults to emerge in the spring. In cases of mild weather during the winter adults might emerge and oviposit. Nothing has been done to prove whether the same conditions hold for the colder northern regions such as Minnesota. Jepson, at Cambridge, England (1909), was unable to carry pupæ through the winter successfully. Newstead in 1909 stated that the most recently emerged flies in autumn may hibernate. On dissection such flies are found to have the abdomen packed with fat bodies in the autumn, but not so in the spring. In 1913 Hewitt confirmed these observations. In a later paper in 1915 Hewitt in some observations on the migration of fly larvæ made in the early spring near Ottawa stated that not a single living pupa was found in the manure or in the soil about the manure pile. He therefore returned to the older theory that the fly overwinters in the adult state in a dormant condition where there is sufficient shelter to protect it from a killing degree of cold, or in places where the temperature and food conditions are suitable to keep it periodically or permanently active. He suggests that the immature stages may survive the winter where temperature and food conditions are favorable, as will be often found in warm stables. Lyon in 1915 in Massachusetts was unable to secure the emergence of adults from puparia exposed to outdoor conditions over winter, although it was a mild winter.

That flies can be bred during winter under suitable conditions is a

[1] Paper No. 78, Journal Series, Minnesota Experiment Station.

well-known fact, first brought to notice probably by Jepson in 1909 when he bred them in a greenhouse. Since the winter of 1914–15 flies have bred each winter in the animal room connected with the Minnesota University Insectary, the construction being such that the accumulation of material suitable for fly breeding can be scarcely avoided. Up to the winter of 1914–15 the same conditions held in the bacteriological animal house of the University. The droppings of rabbits and guinea pigs collected in corners and not being cleaned out for long periods, furnished breeding places for both *M. domestica* and a few *Stomoxys calcitrans*. Breeding places were also found under water dishes where the spilled water soaked the bedding thus setting up fermentation. Regular and more thorough cleaning quickly remedied this condition.

Several observations have been recorded to prove that adult house-flies are rarely taken in winter in buildings or other protected places. In 1913 Copeman reported on three collections of hibernating flies taken in England during March and April. Not a single specimen of the house-fly was found in these collections. In 1914 Copeman and Austen reported on fifty-eight consignments of hibernating flies sent to them from widely distant parts of England. Out of a total of ninety-four flies, twelve proved to be *M. domestica*. These were taken during January, February and March, each time in an active state in living rooms or heated rooms. Ashworth, 1916, states that no adult house-flies can be found in Scotland during the winter.

Since most of the observations on this subject have been made under climatic conditions somewhat milder than those found in Minnesota, with the exception of those by Hewitt at Ottawa (1915), data collected here during the past three years may be of interest.

Temperatures in Minnesota often reach −25° to −30° F. and remain below zero over considerable periods in mid-winter. Flies continue to breed in Minnesota until late in October or early November, the adults lasting until the first heavy frost in November when those die which have not been previously killed by *Empusa muscæ*. Individual adults of both sexes have been taken during the months of December, January, February, March and April, always in houses, or restaurants where temperature and food conditions would be favorable. In stables flies of several species begin to appear by mid-April as a rule, but the house-fly has never been taken among these early forms. A total of nineteen flies have been taken in this way, eleven females and eight males. These flies always looked fairly fresh with wings unbroken. The number seems almost negligible, but when we consider the limited field of observation of one or two people, there must be a fairly large number of flies thus surviving each winter. Flies do not

become noticeable before the middle of June or early July and are not abundant before mid-July. If only a very few survive the winter this would account for their later seasonal appearance.

To test the ability of adult flies to live throughout the winter the following experiments were conducted:

Just before frost appeared, on October 31, a quantity of larvæ and puparia were collected and about two hundred were placed in each of several jars, containing a little moist soil covered with a layer of fresh manure. These jars were placed in breeding cages and the cages in different places, where conditions were such as have been thought suitable for overwintering of the flies. As soon as the flies had emerged they were fed regularly with fresh banana and water. The places chosen were (1) a cellar where the temperature averaged 62°, the lowest recorded being 50°; (2) a stable at the dairy barn, where the temperature never went below the freezing point and only once during the winter approached that point, averaging 45°; (3) an unheated storeroom. Heat entered the latter through an open transom, keeping the temperature above freezing. In this room a large number of flies were also set free. In all six cages of flies were used in this test. Adults began to emerge November 11. In the cellar they were all dead by November 23. In the stable a few survived until February 6. In the storeroom a sudden fall in temperature on December 14 caused the death of all the flies. No thermometer was available to record the temperature, but it was above freezing. Several cages had also been prepared, packed with folds of cheesecloth in which flies could hide away. These were placed in various stable lofts and covered with hay. Where the temperature of the loft was that of the outdoors, the flies died as soon as the temperature approached freezing; in the lofts where the temperature remained higher the flies survived until early December by which time the weather had become cold enough to lower the temperature of the loft to near the freezing point.

During the summer of 1914 several attempts were made to find the reaction of various stages of the house-fly to low temperatures. As no constant temperature apparatus was at our disposal we secured the privilege of using a cold storage plant in town. Temperatures of 12°, 30° and 40° F. were available. Week intervals were necessary between examinations. Adult flies were placed in quart fruit jars containing strips of paper for supports and with cheesecloth tied over the top; larvæ and pupæ were placed in moist soil and manure in wooden boxes 3½ x 2¾ x 2 inches in size. Several of these boxes were placed inside a larger one for convenience in handling. Twenty-five adults were in each jar and 100 larvæ or pupæ in each box. Exposures at 12° F. for one week were fatal to adults, but one male survived

exposure for one week at 30° F. and one female survived a week's exposure to 40° F.; all others died even with these short exposures. Of the larvæ, none survived a week's exposure to 12° or 30° F., but three larvæ survived one week's exposure to 40° F. and two adults emerged, the third dying. Longer exposures at 40° F. were fatal. Pupæ were killed in one week at 12° F.; at 30°, 23 survived and produced adult flies, but all died at longer exposure than one week; at 40°, 21 survived and produced adults, but none were able to endure more than one week of such cold.

The objection may be raised to this that the change from the outdoor temperature of July to that of the refrigerator was too sudden. The double packing of the cases would tend, however, to reduce this danger and make the change more gradual. It would seem from these observations that the house-fly in all its stages is very sensitive to low temperatures, a temperature of even 40° F. causing death if long continued.

To further test the ability of larvæ or pupæ to survive our winters, several thousand half-grown to full-grown larvæ were secured on October 15, 1915. An outdoor breeding cage 4 x 4 x 5 feet was transformed into a manure heap. Four twelve-inch flower pots were sunk in the soil and filled with fresh manure. Into these were placed the fly maggots, after which a covering of about twelve inches of fresh manure was placed over the entire floor of the cage. The larger maggots pupated very soon and large numbers of flies emerged before frost came. On May 15, 1916, after several *Lucilia* and *Sarcophaga* had emerged, the manure was removed and the contents examined. About 25 per cent of the puparia had not produced adults in the autumn previous, but in every case these had died and the contents begun to decompose.

In the springs of 1914 and 1915 careful searches were made about manure piles and compost heaps on the University Farm and elsewhere, but not a single live puparium was found in the manure or surrounding soil. In the spring of 1917 a third attempt was made to find puparia. The manure from the University Farm stables is placed in a compost heap which by autumn reaches a size of about two hundred feet long by three to ten feet high and fifteen feet wide. On April 17 a few puparia were found in the dry manure on the east edge of the pile, but more in the soil under the center, near the north end, where the manure was about three feet deep. They all looked quite fresh, some still possessing a ruddy or yellowish color. A total of 1,646 of these apparently live pupæ were collected and taken to the laboratory. By May 15 not an adult *M. domestica* had emerged, although one *Scatophaga stercoraria* and one *Sarcophaga sp.* had

emerged. Up to June 10 no adults were seen about the compost heap or in houses although a very few were present in the stables, averaging ten to twelve to a stable.

From these observations it would seem that the temperature of Minnesota winters is not favorable to the overwintering of the house-fly in any except the adult stage and that stage only in places where there is a sufficiently high temperature and where food conditions are favorable.

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AN IMPROVED METHOD OF REARING TABANID LARVÆ

By WERNER MARCHAND,
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The Tabanidæ are a group of considerable economic importance and it is desirable for the study of their bionomics as well as for experimental purposes to follow more practical methods in rearing them than has been the case up to the present. Only a few larvæ at a time have been reared by authors, and these were usually placed in damp earth to provide them with an environment as close to the natural one as possible. In fact, from De Geer (1760) to the more modern investigators, notably C. W. Hart (1895), J. S. Hine, who beginning in 1903 has studied the life-histories of several American species, Lécaillon in France, who studied *T. quatuornotatus*, and others, the larvæ have always been reared in damp sand. Hart seems still to have used breeding-cages or boxes of some size, while Hine is the first to propose jelly-glasses, as of more convenient size and having other advantages. In such jelly-glasses, the cover of which was perforated with a few holes, Hine succeeded in raising *Tabanus lasiophthalmus* from the egg to the adult. Of still more recent investigators, H. H. King (1910) and others have followed Hine's method with small modifications according to circumstances. S. A. Neave (1915) used vessels, made by the natives of the African locality where he made his studies, which were filled with damp sand in much the same way. Patton and Cragg, who wished to raise large numbers of Tabanidæ in India without giving much time to their feeding, proposed the use of trays of very large dimensions in which, even in the case of highly carnivorous larvæ, a certain percentage will reach maturity.

All these methods have the disadvantage that the larvæ are kept in sand and consequently cannot be conveniently observed. Their presence can be ascertained only by washing them out of their sandy habitat which takes considerable time and also disturbs the larvæ; small larvæ are easily overlooked and lost; larvæ in the act of pupation, or shortly afterwards when the pupæ are soft, are often damaged, etc. As, most of the time, the larvæ are not visible at all, details of feeding habits or molts of the larvæ have hardly ever been noticed and the exact time of pupation and consequently the duration of the pupal period could seldom be determined.

When beginning an investigation of the life-history of these flies, I found that the larvæ of a number of species, and probably of most of them, do not need earth or sand for their well-being, but can be kept very conveniently in test tubes laid out with a rolled-up sheet of filter

paper, somewhat less than the length of the test tube and filled with water to about one-half to one inch high, which is sufficient to keep the filter paper moist for a number of days. The test tubes used are about seven and three-quarter inches long with a rolled edge. To prevent the larvæ from escaping, a piece of cheesecloth is tied to the open end by means of a small rubber band.[1] The larvæ will often hide between the sheets of the paper or on the inner side of it, but about as often come to rest between the paper and the glass walls of the tube where they remain for days plainly visible in all their activities and where they can even be examined microscopically. Molts cannot be overlooked as the shed skins appear plainly on the white surface. In the same way excrements may be readily observed and taken out with the paper for examination. Earthworms may be given as food with the advantage that they move about in the test tube and are soon found by the larvæ, but meat proved an excellent substitute and was readily taken by all the larvæ under observation. This is of some importance as earthworms cannot always be had and the feeding problem then becomes difficult. Food should be given every two or three days but the larvæ can go without food for a much longer time.

Hine has stated that a disagreeable odor developing in the breeding jars seemed to be injurious to the larvæ. I have found, however, that the larvæ did perfectly well even in the presence of highly putrefactive and ill-smelling matter, and were not affected by the presence in the tubes of dead earthworms, decaying meat, etc. Nothing needs to be feared in this respect for the larvæ as long as they have air to breathe. In one case only a larva died, evidently in consequence of an infection, after remaining in contact with a piece of meat for several hours. In another case a pupa of *T. lineola* was seen in contact with a lump of decaying meat for several days and then moving away from it by itself. The larvæ will sometimes drown in the water of the bottom of the test tube, but even when apparently drowned will often revive when placed in air again.

I notice that M. B. Mitzmain (1913) in his excellent studies on *T. striatus*, placed larvæ in jars with sheets of filter paper which were partly soaked with mud. He also saw the larvæ congregating between the filter paper and the glass walls of the jar, and he is the only author who observed several molts in Tabanid larvæ. A. Lutz (1910) used damp moss instead of mud and glass vials to render the larvæ more visible; and test tubes have, as far as I know, been used by Baldrey (1913) who, however, did not raise many larvæ. The method here proposed, if not absolutely new, appears satisfactory enough to be recommended for more general use especially for the close observation

[1] I find it convenient to keep the test tubes on wooden racks holding twelve each.

of single larvæ, although it would be cumbersome for rearing large numbers. Several dozen, however, can be taken care of easily by one worker with daily inspection of all the tubes.

The damp filter paper gives to the larvæ a perfect substitute for the damp mud in which they usually live and is also similar in contact, facilitating their natural movements upwards and downwards in the tube. They pupate without difficulty in the test tubes and usually in the upper portion of the roll of paper. Pupæ were obtained in this way from four species of Tabanus.[1] The pupæ are easily taken out of the test tubes and placed in other dishes or jars, but two males of *Tabanus lineola* were allowed to hatch in the test tube; of these one had the wings fully developed, and the other one had one wing slightly distorted, having been hindered in its development by the filter paper which had become dry and somewhat hardened. Larvæ of 4 to 5 mm. in length did just as well as those of 40 mm. and more in length. The filter paper is taken out from time to time with a forceps and renewed, but if one wishes merely to keep the larvæ alive and to rear the adults, this may be omitted and all that is necessary is to keep the filter paper moist and to give new food from time to time. When the paper becomes dry or the larvæ are very hungry, they will sometimes succeed in escaping by creeping underneath the cheesecloth in spite of the rubber band holding it, but this happens only occasionally. In fact, the larvæ need very little care and with this rather simple breeding apparatus, it should be a comparatively easy task to obtain detailed data on the life-history of any Tabanid species.

Test tubes have already been used for the rearing of Dipterous larvæ, notably by J. P. Baumberger, for rearing *Drosophila ampelophila* on agar, but for earth- and mud-inhabiting larvæ a convenient method was lacking. The test-tube-and-filter-paper method may prove useful for the rearing of many such larvæ, as those of Tipulidæ, Stratiomyiidæ, possibly of Lampyridæ, etc.

A few words may be added here about collecting the larvæ. I have first followed the method employed by Patton and Cragg, who recommend using a pail in which mud and sand from the edges of rivers and ponds is mixed with water and thoroughly stirred and the muddy water then sifted. Those larvæ which are able to float appear very soon at the surface; the others have to be obtained by sifting. Finding it inconvenient to wander about with a spade and pail, taking samples from different localities, I soon contented myself with an ordinary kitchen sieve by means of which excellent results may be obtained with very little trouble. Moderate-sized lumps of mud and sand,

[1] Since this paper was written, pupæ were obtained of fourteen species of various Tabanidæ: Tabanus, Chrysops, and Haematopota (?).

always taken above the water line but not far from it, are placed with the hands or by means of a small hand shovel into the sieve and worked over somewhat. As soon as the sandy constituents have been washed away the Tabanid larvæ become visible. The sieve need not be excessively fine as even small larvæ instead of going through the meshes will usually cling to the vegetable detritus, grassroots, etc., contained in the mud. As Tabanids are rather common in some localities and the larval stage, being of much longer duration than the imago, is more likely to be found, it will usually take less than half an hour sifting on any pond, brook or stream to find at least a few small-sized larvæ. One need not be discouraged about taking even the smallest ones as the slowness of their growth has been much exaggerated; it is not slower, for instance, than in many lepidoptera with a one-year's life-cycle.

For transportation, the larvæ should not be placed in water but in some wet material in which they can hide. Unless abundant food is given, the larvæ should be isolated because of their cannibalistic habits.

AN INFESTATION OF POTATOES BY A MIDGE[1]

(DIPTERA, CHIRONOMIDÆ)

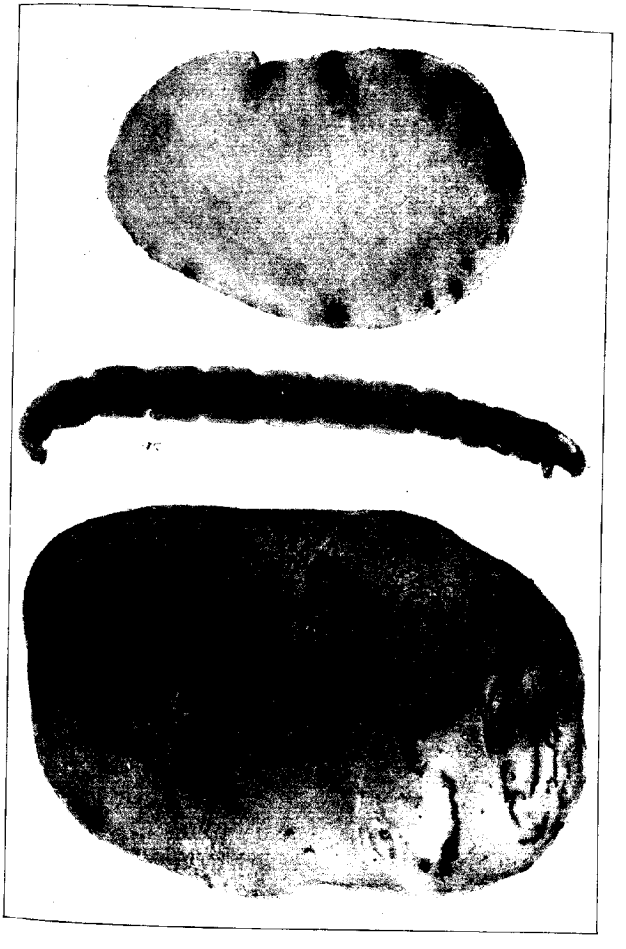
By EDITH M. PATCH

A record of a Chironomid larva, in the rôle of a potato miner, may be of sufficient interest to justify transferring it from the notebook to the printed page.

On October 25, 1913, potatoes of the appearance shown in the accompanying photograph were received from Roxie, Maine, with the statement that they represented the condition of an infested acre. The trails contained numerous dipterous larvæ so different from any pest known to the writer that it was at first suspected that they had worked into mines made by something else and that their presence was accidental. That such was not the case was testified by the larvæ themselves when a cut tuber was placed under the microscope. The exposed miners were busily tunneling down into healthy tissue. As they worked they moved the ventral flap under the head up against the mouthparts. Some of the trails lay under the skin near the surface of the potato and were apparent as soon as the tuber was washed. Others extended for some distance into the vegetable, as is shown in the figure of the potato cut in half.

The larvæ were three-sixteenths of an inch in length. They were

[1] Papers from the Maine Agricultural Experiment Station: Entomolgy 92.



Larva of Chironomid greatly enlarged, and its work in potato.

abundant in the trails, where frequently as many as fifteen or twenty could be found together in the wider places, though the narrow mines seemed to be the work of single individuals.

On the chance of the situation proving serious, the case was reported to the State Department of Agriculture and a barrel of infested potatoes was requested by the Station for study. The following quotation is from a letter by the grower of the potatoes:

"Have sent you today by express a barrel of the potatoes, as directed. In answer to your questions will say: The seed was bought of a farmer about four miles away from this place last year and planted on this farm but not on the same field. Bought them for Gold Coins but they are mixed with other varieties. Had no trouble with them last year. This acre was between two other kinds neither of which seemed to be affected. The land was in hay four or five years and was broken last spring (1913) for potatoes and used Armour's fertilizer. Was top dressed in 1911 with barn yard manure. . . . There are two other farms near here where potatoes affected in the same way have been found."

The maggots lived in this shipment of potatoes for a fortnight or so but no pupæ were obtained and by the middle of November none but dead larvæ were found.

A specific determination was not possible on the data presented, but Dr. O. A. Johannsen kindly examined the larvæ and pronounced them "probably *Camptocladius* sp."

No similar occurrence has come to the attention of the writer since this record for 1913 and it is hoped that the attack was due to some peculiar local condition which may not again prove favorable to this midge in its career as a serious pest of potatoes.

THE COCOANUT-TREE CATERPILLAR (BRASSOLIS ISTHMIA) OF PANAMA[1]

By L. H. DUNN, *Entomologist, Board of Health Laboratory, Ancon, Canal Zone*

Cocoanut culture on the Isthmus of Panama may be safely ranked as an important industry, and bids fair to become more so in the future. At the present time in nearly all parts of Panama cocoanuts are grown to a greater or less extent, ranging from the few trees near a native's hut to large and profitable groves, covering many acres of ground and owned by large companies.

For numerous reasons this industry on the Isthmus does not have

[1] Read before the Medical Association of the Isthmian Canal Zone, January 22, 1916.

the commercial importance that it is likely to have in the future. More people will come here following the successful operation of the Canal, to engage in agricultural pursuits and it is safe to say that a great many more cocoanuts will be exported than at the present time, as they are one of the safest products to handle in Tropical America provided facilities for transportation and shipping to the markets are convenient.

After the young trees in a grove are well started the principal care required is to combat the insects that are injurious to them, as the trees in this region are singularly free from the diseases that cause much damage in other parts of the country and it is with one of the injurious insects that this article is concerned.

The most destructive insect enemy of the cocoanut tree, *Cocos nucifera*, in Panama is the lepidopterous insect, *Brassolis isthmia*, in its larval or caterpillar stage. This insect is a native of Panama and as far as can be ascertained is found in no other region.

I have been studying this pest twice a year (seasonally) for the past two years, but for the most part only during spare hours, and have not been able to devote the amount of time to this work that is necessary to make a thorough investigation of their habits, and also have not had the opportunity to do much field work in this connection which is highly essential in a life-history, but I will endeavor to set forth a few results obtained from work done at the Laboratory and observations I have been able to make on the cocoanut trees in the Ancon Hospital grounds.

History

Brassolis isthmia was first recorded and described by Bates[1] in 1864. It belongs to the genus Brassolis, which, according to Westwood,[2] contains four species that are very closely allied, but differ in their habitat. *B. isthmia* is recorded only from the Isthmus of Panama. *B. sophorœ* is found in British Guiana, and *B. astyra* in Brazil. I have not been able to secure much information regarding the habitat of the fourth species, *B. macrosiris*.

In 1908, Shultz[3] published an excellent article on *B. isthmia* giving information regarding their life-history, habits, and damage caused by them, which is the only information on the life-history of these pests to be found in the literature at hand.

[1] Bates, The Entomologists Monthly Magazine, vol. 1, p. 164, June, 1864.

[2] Doubleday & Westwood, Diurnal Lepidoptera, vol. 11, p. 350.

[3] Shultz, Henry F., Proceedings of the Entomological Society of Washington, vol. X, March–June, 1908, p. 164.

General Description

Egg.—The eggs are somewhat spheroidal in shape, or slightly flattened on two sides. They are about one millimeter in diameter, and average in weight about 1.4 milligrams each. When newly deposited they are white with a yellowish tint.

Larva or Caterpillar.—The newly hatched caterpillar is red in color, the shade becoming reddish brown over the head. The body is only about half the diameter of the head. If examined with a lens they may be seen to have three narrow light colored stripes extending from the head to the posterior segment. The young caterpillars are about 4 millimeters in length and 0.5 millimeter in diameter. The diameter of the head is approximately one millimeter. The average weight about two hours from time of emergence from the egg is one milligram. When full grown the caterpillars range from 7 to 10 centimeters in length, and 10 to 12 millimeters in diameter. The weight, when mature, varies from 2½ to 4 grams. The head is quite large and prominent and is hard and shiny, the color being from red to dark brown. The apex and center of the head being lighter in color than the cheeks. It is somewhat longer than wide, being about 7 to 9 millimeters long and from 5 to 7 millimeters wide. The body tapers slightly to both ends and has a ground color of dark brown, ornamented with three yellow longitudinal stripes running the full length of the body, one stripe on the dorsal surface and one on each lateral surface. The stripe on the dorsal surface is about 4 millimeters wide, with light colored outer edges, and the center having minute lighter colored spots, giving the center of the stripe a slightly freckled appearance. Each stripe on the lateral surfaces has two thin intermediate dark colored stripes running the full length and the outer portion of the stripe having the freckled appearance as the one on the dorsal surface. Each of the segments are ringed with thin light colored markings which can be noticed upon close examination. A number of fine short brown hairs are scattered over the body as well as many longer white ones. The dorsal surface of the caterpillars vary in color from light red to dark brown (according to the age) and the red color changes to brown when nearing the pupal period.

Pupa or Chrysalis.—The chrysalis during the first few days of pupation varies in color from light gray to a faint purple, with many darker markings of dark brown on the head and wing covers. The abdomen is rounded dorsally and pointed at the posterior end, and has one regular stripe varying from light blue to brown running the full length of the chrysalis from the head to the end of the abdomen, with a faint blue irregular stripe on each side. Four dark brown stripes on the ventral side extend from the wing covers to the end of the abdomen. The segments near the base of the wing covers are somewhat telescopic in character and allow a considerable amount of motion. The chrysalis is smooth and somewhat shiny and is from 2½ to 3½ centimeters in length, and from 10 to 15 millimeters in diameter, and averages in weight from 2½ to 3½ grams. The female chrysalids are somewhat larger than the males.

Imago or Butterfly.—The butterfly is dark brown in color on the dorsal surfaces of wings, thorax, and abdomen; all ventral surfaces being several shades lighter. A pale brownish yellow patch, one centimeter wide, extends across the fore wings from the costal margin to within a very short distance from the anal margin. This patch has a small angular spot of dark brown extending into it from the costal border. The ventral surfaces of the fore wings have the same yellow patch that is seen on the dorsal surface, and also has a narrow convoluted line, with dark edges, extending along the lateral margin of the wings. The ventral surface of the hind wing has three small round spots, arranged at nearly right angles, several shades lighter than

the surrounding area; the spot in the anal angle being the largest and having a narrow black margin, and small shadings of white within the front border of the black margin. The body is densely hairy. The female butterfly has a wing expanse of from 9 to 10 centimeters. The antennæ are from 15 to 18 millimeters in length and slightly bulbous at the tips. The legs are dark colored and the anterior pair are short and held folded and apparently not used in any way. The gross appearance of the males differ from the females by being a shade lighter in color, and the angular dark spot in the yellow patch on the dorsal surfaces of the fore wings is fainter. The circular spot on the anal angle of the ventral surface of the hind wing is also somewhat smaller than that of the female.

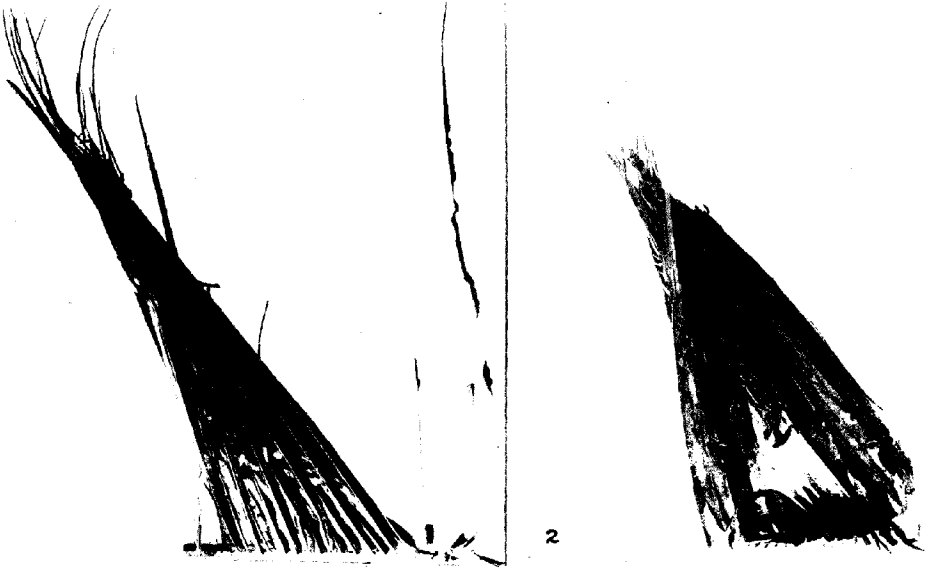
Injury Caused

This pest is only injurious to the cocoanut tree while it is passing through its larval or caterpillar stage, at this time their food consists of the leaves of the tree. These caterpillars form long bag shaped nests of the leaflets by fastening the ends together and spinning a silken lining on the inner side and live in great numbers in these nests. It is safe to estimate that the average nest contains about 400 caterpillars, and as the average tree only has from 15 to 30 leaves it is needless to say that if left in the tree the full grown caterpillars living in one nest will very quickly either completely defoliate a tree leaving nothing of the leaves but the large main stalk and the slender midribs of the leaflets, or destroy enough of the foliage to cause serious injury to the tree.

In beginning an attack upon the long leaflets the caterpillars invariably commence to feed at a point about half way between the end that is fastened to the main stalk of the frond and the free end of the leaflet. The eating of the borders on either side of the leaflet to its midrib at this point, even though the entire width is not severed, soon causes the outer end to wither as it interferes with the circulation of the juices beyond the place where the caterpillars do their feeding. Frequently it eats its way through the midrib of the leaflet and this completely amputates the distal end which falls to the ground and is never utilized as food for the insect. Thus in three ways it may bring about the destruction of the leaflet, *i. e.*, consumption of the entire leaflet; amputation of distal half of the leaflet; and interference with the circulatory system of a portion of the leaflet. In many instances nests may be located in trees by the appearance of the ground beneath it. The ground below a large nest of full grown caterpillars is sometimes nearly covered with the ends of leaflets that have been severed at the middle. Through this habit of feeding at the middle of the leaflets, the caterpillars destroy about as much foliage by wastage as by actual consumption of the frond.

It is by no means uncommon to see large trees almost entirely denuded of their foliage, and after a severe attack by these cater-

Cocoanut-tree caterpillar: 1 male; 2 female; 3 caterpillars in prepupal stage and chrysalids; 4 caterpillar.



Cocoanut-tree caterpillar: 1 nest; 2 nest opened.

pillars it requires several years for a tree to recover, if it recovers at all.

In many instances solitary high trees seem to be the most heavily infested, but this may be due to the fact that as the trees are standing alone, some of the females of the previous broods that have lived in the trees deposit their eggs in the same trees without seeking further for a suitable place, and the young caterpillars emerging from the eggs of several females are found to live in one tree in greater numbers than if they were in a thick grove and were able to spread to other trees.

The caterpillars show a decided preference for cocoanut trees and the injury is nearly always confined to the cocoanut palms, but at times they will also attack other trees of like nature. They have been noticed feeding on the Royal palms, but so far no nests have been found in any of these palms that were low enough to examine closely, although in several trees the caterpillars were quite numerous and were generally found during the daytime on the under side of the leaves, or in the pocket at the base of the leaf stalk. From this it would appear that the caterpillars leave the cocoanut trees to seek a suitable place to pupate, and when the palms are selected feed upon the leaves for a few days before pupating.

If one had an opportunity to closely examine the grown Royal palms an occasional nest might be discovered, although there are not likely to be many as no appreciable damage caused by these caterpillars has yet been noted in the Royal palms, at least in this locality.

Life-History and Habits

There are two broods a year of these pests. In the spring the adult females deposit their eggs during May and June, and in the fall during the latter part of October, the whole of November, and the early part of December. It is very evident that the different stages greatly overlap each other, as eggs, grown caterpillars, and adult females ready to oviposit, may often be found during the same day.

In many instances the eggs are deposited on the lower side of the leaves, or on the trunk of the cocoanut trees, but numbers are also found on buildings, or other sheltered places, from which it would appear that the female was more concerned in seeking protection for the eggs from the weather and parasitic enemies, than for a place suitable for the young caterpillars to obtain food upon their emergence.

The eggs are laid in masses, made up of both regular and irregular rows of the eggs. The eggs in one mass may be all in regular rows, and in a second one may be all in irregular rows, while a third mass may be one part regular and the other part irregular rows. Apparently there is not much uniformity in the arrangement of the egg masses. They are laid in very close order and are cemented to each

other and to the surface on which they are deposited by a clear mucilaginous substance which gradually changes to a dark brown in color after it has been exposed to the air for a few days.

The number of eggs in a mass vary considerably, ranging from 150 to 300. This difference in numbers would lead one to suspect that in many instances the female does not deposit all her eggs at one time, but only deposits part in one place and later finds a suitable place to deposit the remainder.

The portions of the eggs not heavily coated with the cementing substance is white with a yellowish tint when first deposited but becomes grayish in color after a few days' exposure to the air. About 3 to 5 days before hatching a small dark spot appears in the center of each egg.

The egg stage extends over a period of from 25 to 30 days duration. At the end of this period the young caterpillars eat their way out of the egg shells and emerge head first.

The caterpillars that have emerged from all egg masses that have been hatched in the Laboratory have eaten the egg shells and all the gummy material used in fastening the eggs together soon after they have emerged. Nearly all parts of the shells are eaten excepting the part cemented to the leaf or surface to which they are fastened. Eggs from which the young caterpillars have not yet emerged are not eaten by those already hatched.

When bred in jars the young caterpillars after making their first meal on the shells from which they have emerged soon begin to travel around the sides of the jar in lines of single file, each close behind the other, and leaving a small trail of silk behind them. This is continued sometimes until the inside of the jar is about completely lined with silken floss.

During this stage when the newly emerged caterpillars that have hatched away from a cocoanut tree are endeavoring to reach their food supply, a great many are undoubtedly destroyed by birds, toads, lizards, ants, etc., and it is not likely that very many ever do succeed in reaching a cocoanut tree, and those that emerge from eggs deposited on the trees are the ones that are responsible for the greater amount of damage done, and for the succeeding generations, but even if a very few of the young traveling caterpillars do reach a tree that is not already infested they can lay the foundation for a considerable amount of damage.

For some time after emerging the caterpillars do not seem to cause any appreciable amount of damage, but as they continue to grow the damage likewise grows in proportion, and when full grown the numbers in a large nest can destroy nearly all the foliage on a tree in a few nights, and it is at this time that they attract attention the most.

Before reaching maturity they always gather in large numbers and build nests for themselves. This nest building habit of these caterpillars appears to be peculiar to themselves as there seems to be no record of any other lepidopterous insects utilizing leaves to form a nest to the same extent as the *B. isthmia* does.

The nests are formed by bringing the ends of the leaflets on opposite sides of the main stalk of a leaf together so that they extend downward, and at the lower end the narrowness of the leaflets give to the whole affair the appearance of a long funnel shaped bag. The leaflets are fastened together with a silken web spun by the caterpillars and they also line the entire nest with an inner lining of this silk. Many of the large nests are divided into several compartments by having partitions of this silken floss extending longitudinally in the nests. This inner lining of silken web does not reach to the ends of the leaflets forming the nest, thus leaving openings at the bottom for all the excrement within the nest to drop to the ground.

As the leaflets of a cocoanut tree extend at nearly an obtuse angle it evidently requires considerable skill to bring the ends down and together in order to fasten them in the positions they occupy in the nests, and this is probably accomplished by the weight of large numbers of the caterpillars.

Close observation of this nest building has so far been impossible. The low trees which would permit of such observation have been remarkably free from infestation, and for the higher trees neither the time nor the necessary conveniences have been available.

One nest recently examined was 4 feet and 4 inches in length and 14 inches in width at the top, measuring over all the leaflets fastened together. Thirty-three leaflets were fastened together to form this nest, 16 on one side and 17 on the other.

The number of caterpillars found in a nest varies greatly, ranging from as low as 50 up to as high as 2,000. Apparently a great deal depends upon the size of the nest and the time that it is cut down. Undoubtedly, in a small nest, many of the caterpillars, finding their quarters overcrowded, emigrate to large nests in close proximity, or there may have been only a small number to start with when the nest was begun. Nests that are cut down late in the season are liable to contain smaller colonies than those found earlier, as they are then full grown and many may have already left the nest to find suitable places for pupation.

In the particular nest just mentioned, 615 caterpillars were found. All were full grown and ready to pupate and there were probably many more that had left the nest to pupate before it had been cut down.

Usually there are but one or two nests to be found in a tree, but

there may be as many as five or more in a large tree that is badly infested. Five were found in one tree recently, three of these were large and each probably contained several hundred caterpillars, the other two were both small ones.

It is possible that these nests are built as a protection against the hot tropical sun and heavy rains. Some of them seem to be nearly watertight as several recently examined were cut down shortly after a heavy rain and in each one the inner sides of the nest and the mass of caterpillars inside were found to be quite dry, but this is not likely to apply to all the nests as some have been found that were poorly built, and late in the season as the caterpillars begin to reach their maximum growth they quite often eat large holes in different parts of the nests.

The caterpillars are nocturnal in habits and remain in the nests during the day and come out to feed only at night time. They may be observed during the daytime only late in the season when they leave the nests and begin seeking a place suitable for pupation.

Owing to the height of the trees and this habit of hiding during the daytime, the caterpillars would not be noticed in a tree thick enough to hide the nests, except for the ends of the leaflets on the ground under the nests and the destruction of the leaves, unless a close search was being made for the nests.

In the spring they usually attract attention about the latter part of February or March, by the leaves being so badly eaten that they are readily noticeable. In the fall they are noted about July or August.

All of the caterpillars hatched in breeding jars died before the first molt, and owing to the fact that none could be reared to the chrysalis stage it was impossible to ascertain the number of molts during the caterpillar stage.

They complete their growth in about four months. The fall brood sometimes extends over a longer period of time. Of course much depends upon the food supply and temperature and humidity may also play a part in governing this period of their life.

During April (in the spring) and September (in the fall) the large full-grown caterpillars begin to leave the trees and seek places to pupate. They can then be observed traveling along the walks and roadways at a rapid gait. Even at this period they show a desire to avoid the bright sunlight as much as possible, and when crawling on a walk or road or any place cleared of grass and shrubbery seem to be moving quite rapidly, but when in the grass or bushes to hide them from the light they lessen their gait and travel more slowly.

A few of the caterpillars remain in the trees and pupate there, but these represent only a small percentage of the whole number. Those

that do pupate in the trees usually attach themselves to the trunk of the tree or outside wall of the nests, and seldom are found as chrysalis inside the nests or in the pockets formed by the base of the leaves.

The large numbers that leave the trees seem to select a variety of places in which to pupate, such as beneath the overhang of roofs, under boards on fences, on verandas, trees of different kinds other than cocoanut palms, and in fact they are found in all manner of out of the way places. The principal point that they appear to have in view is a place that is dry and protected from the weather.

When about to transform to a chrysalis the caterpillar fastens itself to any under or side surface by the posterior end with a webbing of fine silk and hangs head downwards. It seems to require about 24 to 48 hours for this transformation. During the first 12 hours the caterpillars hang curled up and slowly contract longitudinally and swell out at the upper or anal end. As the chrysalis forms inside and draws away from the head of the caterpillar skin it leaves the lower head end of the skin empty and collapsed. After about 12 hours or more the larval skin starts to split lengthwise down the dorsal surface and the round portion of the chrysalis begins to emerge and by a sharp jerking motion soon endeavors to free itself from the cast skin. This may sometimes be loosened from the chrysalis and fall to the ground, or other times it may hang attached to the webbing of silk, holding the chrysalis to the wall or place of attachment, and dry up.

After just pupating, the chrysalids often have a light red tinge to their color which gradually darkens as they become more mature.

The length of the chrysalis stage is from 14 to 17 days. At the end of this period the shell splits and the adult butterfly emerges.

Out of one lot, consisting of several hundred of these caterpillars, that was collected and placed in separate jars and bred out in the Laboratory, 53 per cent of the adults that emerged were females, and the remaining 47 per cent males. Seventy-eight per cent of the males had a 15-day chrysalis period, and 68 per cent of the females had a 16-day chrysalis period. This would tend to show that the males emerge a little earlier than the females. The chrysalids that are late in the season seem to have a day or two shorter period than when pupating earlier in the season.

For the first few hours after emerging the adult clings to the empty chrysalis case until its wings become dry and straighten out, and it is then ready to begin its existence as an adult.

Since the eggs begin to form in the females during the chrysalis stage at about the sixth day, the adults emerge with eggs almost fully developed and it only requires copulation to fertilize them and then they are ready to be deposited.

The female butterflies can readily be distinguished from the males as soon as they emerge from the chrysalis case, because the large number of eggs contained by the female greatly distends the abdomen. The chrysalids, near the time for emergence, offer some evidence of sex differentiation since the females are larger than the males.

Few of the adults are to be seen in flight excepting at night or late evening, and are then sometimes seen in numbers. The few that are to be noticed in the daytime are generally females and are supposedly seeking a place to deposit their eggs. It has been impossible to obtain any data on the feeding habits of the adults.

There appears to be a variation in numbers between the spring and fall broods. In some seasons the spring broods are the greatest in numbers and do the most damage and the fall brood may be very small, and the following year it may be the opposite and the greatest damage may be caused by the fall brood. This difference may probably be caused by the methods of control applied and also be influenced by the action of parasitic enemies.

The fall broods seem to have a slightly longer caterpillar period, but as they are in this stage during the dry season of the year in Panama, it may be that this tends to lengthen the period.

Preventive Measures

Methods of control such as spraying, etc., that ordinarily proves effective with leaf eating insects in the Temperate zones are almost impossible in this case. While these caterpillars are leaf-eating and should be susceptible to stomach poisons, their environs render the application of such poisons as expensive and useless procedure.

The spraying of cocoanut trees is impractical in Panama especially during the rainy season, and the height of full-grown trees causes spraying to be tiresome and extremely difficult at any season. It is either necessary to use long extension pipes with a nozzle on the end and these are generally so unwieldy that it is difficult to direct the spray. Long ladders might be used with a man at the top of the ladder with a short spray pipe connected with a rubber hose to the pump. This is also an unhandy manner of working as the man is then directly under the foliage to be sprayed. In either case a very strong pressure is required to give necessary force to the solution at such a height. Even if a spray could be applied by some easier method the sudden and heavy rains so common in this region would be liable to wash it off almost as soon as applied.

Owing to the nesting habits of these caterpillars and to their remaining hidden within the nests during the daytime, if a little care is exercised they may be kept under complete control by the removal of the nests with the caterpillars inside.

When trees are infested with these pests the most practical method of disposing of them is by going up in the trees by means of long extention ladders that will reach to the tops of the trees and cutting down the nests without disturbing the occupants. They can then be crushed with heavy mortars, or a better way is to throw the nests containing the caterpillars on a hot fire. They may also be killed by dipping in a strong contact insecticide.

While cutting out the nests is about as troublesome as spraying, if done at the proper time it is only necessary to be performed once during a season and will give the most reliable results.

When spraying is the method employed every tree would have to be gone over in order to be effective and to prevent the caterpillars from leaving a sprayed tree and emigrating to one that was not treated, while nest removals require attention only to the infested trees that may be found. The principal point to be observed in cutting out the nests is to be on the lookout and remove them at the proper time. They should be removed early and before the caterpillars have become fully grown. If they are neglected until the caterpillars have become mature many will have left to pupate by the time the nests are removed and naturally will develop into adult butterflies and propagate the following season.

Cutting down the nests is the method that has been adopted with the cocoanut trees in the Ancon Hospital grounds and it seems to have proved effective.

Banding the trees with a sticky substance may prove to be of some value in preventing the young caterpillars that emerge from eggs that are deposited in places other than the trees, from gaining access to them. This may be done by painting a ring about 18 inches wide around the trunk of the tree at some distance from the ground with a thick coat of tar or other sticky material of like nature that is sufficiently waterproof to withstand the heavy rains. This should also be done at the proper season when the young caterpillars are emerging from the eggs.

Natural Enemies

The natural enemies of the cocoanut tree caterpillar may be classified as follows: Insect-feeding birds; lizards; insect parasites; and a fungus disease.

It is very evident that many of the young caterpillars are destroyed by insect-feeding birds, both while on the ground and also while in the trees before the nests have been built to form a refuge for them during the daytime. They are not only eaten by the adult birds but are also carried to the nests as food for the young. As neither the English sparrow or the North American robin are to be found here in any

numbers the birds that come first as insect feeders in Panama are a species of blackbird, but it is not likely that more than a small percentage of each season's brood are destroyed by birds.

As lizards are insectivorous in their feeding habits to a large extent, is reasonable to suppose that they also destroy many of the young caterpillars by eating them while they are on the ground and also while they are in the trees and before becoming too large, as several varieties of lizards are often to be found in the trees seeking for insects to feed on.

The caterpillars are nocturnal and are most active at night-time, or while in dark places, and it may be supposed that many of the young ones that emerge from eggs away from the trees, and while endeavoring to reach the trees, and also many of those that are full grown after leaving the trees and while on the ground seeking a place to pupate, fall an easy prey to toads, as they are very numerous in this region, and are both insect feeders and feed largely at night as well. Toads that were in captivity ate eagerly of half-grown caterpillars when given to them.

Parasitic insects undoubtedly destroy a larger percentage of *B. isthmia* than any of their enemies just mentioned and may be classed as second in importance of their natural enemies as a control of this pest. These parasitic enemies destroy the B. *isthmia* while they are in the chrysalis stage. Some of the parasitic flies deposit their eggs or living larvæ either on, or near enough to, the chrysalis so that the young larvæ may enter it without much trouble and feed on the soft-bodied insect and destroy it. Other flies inject their eggs directly into the chrysalis and the young larvæ emerge from the eggs inside and promptly proceed to devour their host.

The adults of these parasites come under two orders, the Hymenoptera or four-winged flies, and the Diptera or two-winged flies. The small Chalcid flies are the principal hymenopterous parasites, and the dipterous parasites belong to the *Sarcophagidæ* and the *Tachinidæ*.

Unfortunately none of these parasites are peculiar to the *B. isthmia* alone, they are simply accidental or occasional hosts, the flies selecting them as food for their larvæ as they might select chrysalids of many other lepidoptera belonging to different families.

It is to be deplored that the caterpillars have an opportunity to do all their damage before pupating and allowing these parasites a chance to get in their work, but at any rate they help to decrease the brood the following year.

The most important of all the natural enemies is a fungous disease that attacks both the mature caterpillar and the chrysalis. This fungi causes a high mortality among these pests every season, espe-

cially during a period of heavy rainfall or when they are exposed to much dampness. The fall brood seems to suffer a heavier loss than the spring brood, which may be accounted for by the fall brood becoming mature during the middle of the rainy season of the year and there is a much heavier rainfall than when the spring brood are in evidence.

Many are found dead in their nests of this disease and are generally found either in the bottom of the nests, or hanging from the sides suspended by the second or third pair of prolegs and the anterior and posterior ends of the body hanging downward in the shape of a horseshoe. Nearly all of the dead caterpillars become heavily coated with this fungus a short time after death, while the chrysalids become very hard on the inside from the heavy growth of the long filaments of the fungi.

Observations were made on one lot of about 1,000 caterpillars that were collected and placed in a small screened house during the fall season. This house is about 6 feet long by 3 feet wide, and 6½ feet high. Three sides are made of wire screening and the fourth of sheet iron. The roof is made of corrugated iron with screening beneath, which serves to keep the rain out. There is free ventilation in this house and it is comparatively dry with the exception of the floor which is of dirt and becomes quite damp during heavy rains.

Of this lot of caterpillars that were under observation over 65 per cent died as a result of this fungus invasion without changing to chrysalids, and about 50 per cent of those that did transform into chrysalids died in the chrysalis stage. This is a much higher rate of mortality than is likely to be found in a spring brood. It was noted that nearly all of the chrysalids killed by this fungus that were dissected and examined and found to contain females had died before egg formation had begun to take place, and as the eggs can generally be observed in a female after the sixth or seventh day, it would appear that the chrysalids die within the first few days of the chrysalis period. A few were found that contained eggs and these had evidently died later.

It is safe to believe that quite a large proportion of each season's brood are destroyed by their natural enemies.

Laboratory Observations of the Parasitism

In order to discover whether the parasites infest *B. isthmia* in the caterpillar or chrysalis stage considerable observations were carried on at the Laboratory. Shultz[1] in speaking of the parasites says, "I

[1]Shultz, Henry F., Proceedings of the Entomological Society of Washington, vol. X, No. 1-2, March-June, 1908, p. 166.

have not been able to find out whether the mature parasite deposits its eggs cutaneously into the caterpillar, or into the chrysalis, or whether its ova are introduced into the alimentary tract of the larva with its food, as I have found the parasitic larva only in the chrysalids." To determine this point on the parasitization, large numbers of the caterpillars were collected and bred out. Each season when the nests were cut down from the trees several large ones were secured and hung up in the screened house already mentioned and closely observed for signs of parasites. When secured the caterpillars were nearly always mature, which would have afforded ample opportunity for any eggs of the parasites to have been deposited on the skin, or to have been eaten, if that was the manner in which they were parasitized. As soon as pupation began cotton sheeting was tacked around the sides of the house over the screening to prevent any flies from depositing their eggs or larvæ through the screen onto any of the chrysalids that were attached to the screening. Out of approximately ten thousand caterpillars that were collected to be bred out in this manner during different seasons, not a single parasite was found either in the caterpillar stage or in the chrysalids that had transformed inside the house, although all the dead caterpillars and chrysalids that died of fungus or from other causes were carefully dissected and examined. This alone would show that if any were parasitized in the caterpillar stage the percentage must be very small. Aside from this, the fact that the caterpillars remain hidden in the nests during the daytime for the greater part of their lives would help to exclude any chance of being parasitized during this stage.

As proof that the chrysalis is the form attacked, as many of the chrysalids as could be found were collected each season and a large percentage were found to be infested with either dipterous or hymenopterous larvæ. In 1914, during September and October, 106 chrysalids that had pupated out-of-doors in different places were collected and placed in separate jars to breed out. Judging from the time that some of the adults subsequently emerged and from the fact that many had been allowed to remain outdoors for several days after being found, before they were taken inside, the chrysalids had probably passed from 6 to 9 days out-of-doors in the chrysalis stage. Out of this number, 20 were collected from cocoanut trees. Adult butterflies emerged from 14 of this lot, 3 died of fungus, and 3 were destroyed by dipterous parasites.

Sixty-nine were collected from outbuildings in the rear of the Laboratory containing rabbit hutches and small animal cages. These buildings are about ten feet distant from a cocoanut tree and seem to be a favorite place for pupation. Forty-five adults emerged from

this lot, 10 died of fungus and 12 were destroyed by hymenopterous and dipterous larvæ.

Ten were collected from within the courtyard and verandas of the Laboratory. Adult butterflies emerged from 6 of this lot, 1 died of fungus and 3 were destroyed by hymenopterous and dipterous larvæ.

Seven were collected from trees other than cocoanut trees. Adult butterflies emerged from 3 of this lot, 2 died of fungus and 2 were killed by hymenopterous and dipterous larvæ.

The total number destroyed by fungus was unusually small, but being brought into a dry room and placed in separate jars may account for this.

Out of the total of 106 chrysalids, 69 emerged as adult butterflies, 17 died of fungus, and 20 were killed by hymenopterous and dipterous larvæ. Of the 20 destroyed by the parasites, 11 were killed by hymenopterous larvæ, and 9 by dipterous larvæ.

Many other experiments to test the susceptibility of the chrysalids to dipterous larvæ were carried out. Two of these may be worthy of mention. On October 5, a large gravid female fly, *Sarcophaga* sp., was captured on the window in the room where a number of caterpillars and chrysalids were confined in breeding jars.

This fly was placed in a small jar with a caterpillar that was in the prepupal stage, and was curled up and ready to cast its skin in a few hours. On the morning of October 6, the caterpillar had cast its skin and changed to a chrysalis. On October 7, the adult fly was dead, and many young larvæ could be seen crawling on the chrysalis and cast skin, and many more were found feeding on the chrysalis beneath the wing covers when the covers were slightly raised. On October 16, nothing remained of the chrysalis but the empty case, and the larvæ began pupating, and by October 18, had all pupated. Nineteen adult flies emerged during October 22 and 23, and 6 more emerged later on October 25. The whole 25 flies had lived on this one chrysalis during their entire larval period of from 9 to 11 days.

A caterpillar was collected on October 2 and placed in a small breeding jar, and it changed to a chrysalis on October 5. On October 6, a large gravid female fly, *Sarcophaga* sp., was captured on a window in the same room and placed in the jar with the chrysalis of less than 24 hours. On October 7, the fly was dead and one small fly larva was noticed crawling on the chrysalis. On October 8, this larva could not be seen, and no further evidence of any fly larvæ was noticed until October 24, when the chrysalis was examined and found to be but an empty case, and upon being opened 3 dipterous pupæ were found inside. Two of the adult flies emerged October 28.' No adult emerged from the third pupa.

These two instances would show that fly larvæ such as *Sarcophaga*, or other omnivorous larvæ, find no difficulty in entering the chrysalis under the wing covers during the first few days of the chrysalis stage and before the wing covers begin to fit tightly around the edges.

There seems to be a peculiar odor to the chrysalids that attracts flies, and a dead chrysalis proves to be a still greater attraction. Dead chrysalids that happened to be left in uncovered jars and were afterwards examined and dissected were in many cases found to contain large numbers of larvæ of the small flies of the *Phoridæ* family, and the adult flies could be noticed flying around the jars in large numbers after dead chrysalids were left uncovered for a few days.

From work carried out it appears to be definitely proven that this pest is parasitized during the chrysalis period and is free from parasites during the entire caterpillar stage.

Owing to unavoidable causes these observations on *B. isthmia* have not been as complete as could have been wished, but they cover the ground as thoroughly as the circumstances would permit.

I wish to express my thanks to Dr. S. T. Darling, former Chief of Laboratories, for his advice and assistance during nearly the whole of this work; to Major F. F. Russell, Chief of Laboratories, for examining and making cultures of the entomogenous fungi of this pest; to Dr. H. C. Clark for making pathological examinations of chrysalids killed by this fungus disease, and to Mr. J. E. Jacobs, Chemist, for determining all weights given in this paper.

NOTES ON THE LIFE-HISTORY OF MARMARA ELOTELLA BUSCK, A LEPIDOPTEROUS SAP FEEDER IN APPLE TWIGS[1]

By Stuart C. Vinal

For several years the writer has observed quite noticeable serpentine mines in the bark of apple twigs in the vicinity of Amherst, Mass. In 1914 a sample of this work was sent to Washington for determination, and identification showed the sap feeding larva responsible to belong to the genus *Marmara* of the Tineina but the adult moths had never been reared from apple. Accordingly, at the suggestion of Dr. H. T. Fernald, investigation was started during the winter of 1915 with the object of obtaining adult insects and studying the life-history. In July some moths were bred from the apple twig mines and sent to Mr.

[1] Contribution from the Entomological Laboratory of the Massachusetts Agricultural College, Amherst, Mass. This paper is presented as part of a thesis for the degree of Master of Science.

Busck of the National Museum, who identified them as *Marmara elotella* Busck.

Special acknowledgments are due Dr. H. T. Fernald, Dr. G. C. Crampton, and Dr. W. S. Regan for their encouragement and assistance throughout the progress of this paper. For the identification of this species and helpful suggestions the writer is deeply indebted to Mr. August Busck of the United States National Museum and to Rev. J. J. DeGryse of Staunton, Virginia.

History and Ecology

The Tineina, to which this species belongs, constitutes a large and important group of minute moths including many destructive miners. These fall roughly into two distinct classes according to their manner of feeding.

1. Tissue feeders. Those which feed on the internal parenchyma tissue of leaves early in life and later may become external feeders.

2. Sap feeders. Those which mine just beneath the cuticle destroying only a few layers of cells and feeding on the plant sap thus liberated.

This sap-feeding habit has been found only in two families, the Phyllocnistidæ and the Gracilariidæ. The Phyllocnistids are sap feeders throughout their larval life and include the following genera: *Marmara*, *Camermaria*, and *Phyllocnistis*, while the Gracilariids in their early instars are true sap feeders but in later instars become tissue or external feeders and include the genera *Gracilaria*, *Ornix*, *Acrocercops*, and *Phyllonorcyter*.

Many interesting articles have been written based on the specialization shown by these sap-feeding larvæ and their significance in showing evolutionary steps from the more generalized tissue-feeding type. The sap feeders are considered a very highly specialized group and are probably of comparatively recent origin in the Lepidoptera.

Practically all miners confine their feeding to foliage, but a few larvæ of the genus *Marmara*, established by Clemens (*Proc. Ent. Soc. Phila.*, vol. 2, 1863–64, pp. 6–7) mine just under the epidermal layer of bark. Clemens described *Marmara salictella* which "mines the bark of yellow willow tree" and gave a brief account of its life stages. He also described *Marmara* (*Gracilaria*) *fulgidella* (*Proc. Acad. Nat. Sci. Phila.*, 1860, p. 6) mining in twigs of white oak and chestnut. Chambers described *Marmara* (*Phyllocnistis*) *smilacisella* (*Cin. Quar. Jour. Science*, 2, p. 107) bred from leaves of smilax. This species was redescribed with biological notes added by Braun (*Ent. News*, vol. 20, p. 432, 1909). Busck described a new species, *Marmara guilandinella* (*Proc. U. S. Nat. Mus.*, vol. 23, p. 245), mining leaves of *Guilandia*

bonducella in Florida, and in *Proc. U. S. Nat. Mus.*, vol. 26, p. 772, he described *Marmara arbutiella* mining leaves of arbutus trees in Seattle, Washington. In *Proc. Ent. Soc. Wash.*, vol. 8, p. 97, he also described *Marmara opuntiella* mining leaves of Opuntia sp. in Southern Texas. *Marmara* (*Gracilaria*) *elotella* was likewise described by him in *Proc. Ent. Soc. Wash.*, vol. 9, p. 102, but the host plant was not given. A *Marmara* sp. mines orange peels in southern California but the adult has never been determined.

Clemens (*Proc. Ent. Soc. Phila.*, vol. 2, 1863–64, pp. 6–8) claims that *Marmara salictella* changed from the flat mining larva to a more cylindrical form which has fairly well developed legs and prolegs, and escapes from its mine to spin its cocoon in some convenient protected place, this cocoon being covered with a characteristic globular or frothy ornamentation. Busck also ascribes the above habits to *M. opuntiella*, *M. guilandinella*, and *M. arbutiella* although no actual observations were made on the last named species. *M. fulgidella* and *M. smilacisella* it is also claimed form the frothy characteristic cocoon of this genus. *Marmara elotella*, however, differs from all the above species in regard to the formation and situation of its cocoon.

Present Distribution in Massachusetts

An examination of apple twigs at various points throughout Massachusetts has indicated a rather widespread prevalence for this species within the state. It has been found more abundantly, however, in apple trees on the grounds of the Massachusetts Agricultural College and orchards adjoining, than elsewhere. The reason for this localized occurence is unknown.

Character and Extent of Injury

Infested apple twigs show the long, narrow, tortuous, serpentine mines which are very characteristic of all *Marmaras*. They are readily recognized by the yellowish-brown color and slight swelling of the bark over the tunnels, while the normal bark is dark brownish in color. The moths seem to prefer two-year-old twigs upon which to oviposit, usually selecting sucker-like growths. However, the larvæ are occasionally to be found mining in any branch which has a thin, smooth, epidermal covering. The mouth parts of the larvæ are profoundly altered and specialized for living beneath the cuticle of the bark, which they separate from the "greenbark" below by cutting through a row of cells by the action of their circular, saw-like mandibles. From the origin of each mine the tunnel gradually widens from about 0.5 mm. at the beginning, to 7–8 mm. as it nears completion. The average length is between two and three feet. These tunnels do not penetrate

deeply enough to injure the cambium and therefore this species is of little economic importance. Mines similar in character, undoubtedly caused by different species, were seen during the summer of 1916 on poplar, ash, and pine.

Life-History and Description of Life Stages

Egg.—Description:

Oviposition took place during the month of August while the writer was away, and hatching had occurred before his return so that only the empty egg shells have been available for examination. Judging from these the eggs are elliptical in shape, flattened below and convex above. Approximate measurements: 0.7 mm. in length. 0.5 mm. in width.

Location on the Tree.—These tiny eggs are deposited singly on the smooth bark of apple twigs, oviposition for the most part being upon two-old-year wood, and never on the present season's growth. They are apparently stuck to the bark with a secretion of a mucilaginous nature. Eggs are rarely laid upon older wood excepting where the bark is thin and smooth. The period of incubation is probably about ten days.

Mining Larva.—Description of Full-Grown Mining Larva (Fig. 24, 1):

Length 5.5–6 mm., width at first and second segment 1 mm. Dorso-ventrally depressed, body strongly constricted behind the second segment, the remaining segments tapering gradually posteriorly and deeply incised laterally at their junction points. Body semi-transparent, lemon-yellow in color and consisting of thirteen segments excluding head.

Head large, flat, slightly retractile, with dark chitinous supports. Mouthparts very much modified and exserted (Fig. 24, 5). Labrum (lr) fused with dorsal surface of head and immovable. Mandibles (md) large, flat, and circular saw-like with the distal margin serrated. Labium (li) consisting of a chitinous fold distally covered by short spines and extending far back into the head. Maxillæ rudimentary, situated in close apposition to the lateral sides of the labium at its junction with the head. Antennæ (ant) situated on each side of the head near the mouthparts, consisting of two visible segments, the distal one bearing two papillæ, one large and one small, two large papillæ present on second segment with a small one situated in close proximity to a bristle which extends to the apex of the antenna. Ocelli (oc), two pairs with lenses absent, situated posterior to the antennæ. On the lateral margin of the head mid-way between the antennæ and the posterior margin of the head is a stout spine.

Body. First and second segments widest, approximately 1 mm. Third segment narrower than second and fourth. An internal chitinous shield extends from the posterior border of the head into the prothorax and gives this segment a dark brownish color. No legs or prolegs present. Semicircular fold, probably used in propulsion, situated at the posterior extremity. Body without bristles except on first, second and third segments (thorax) where there are two short, stout spines laterally. Anterior fourth of each body segment banded by closely set spine-like protuberances of the body wall. These are directed backward and probably function in bracing the larva during tunneling operations. Spiracles extremely minute but visible with

high power of microscope, near the anterior lateral border of each abdominal segment except the last two. Meso- and meta-thoracic segments (second and third) without spiracles. Prothorax with a spiracle somewhat larger than those upon the abdomen, situated on each side near the posterior margin.

LARVAL LIFE-HISTORY.—It is very difficult to gather data on these interesting sap feeders because the larvæ if removed from their mines are unable to reënter the bark to continue mining and therefore soon die. On hatching, the young larvæ, without exposing themselves, immediately enter the twig and begin their mines which extend partly around the twig before running lengthwise. They molt twice before winter sets in and hibernate as third instar larvæ in their mines, protected from severe climatic changes only by the dead bark covering the tunnel. With the coming of warm days in the spring they resume activity and molt a third time about the middle of May. During June the fourth instar mining larvæ become full grown.

HYPERMETAMORPHISM.—In this species all the mining larval stages are flat, legless, with exserted mandibles fitted only for separating the tissues of plants and not for masticating purposes. In structure all these stages are alike excepting in the proportionate size of the thorax and abdomen. In the young larvæ the head and thorax are much wider in proportion to the abdomen than in later stages.

Upon reaching maturity the mining larva retreats a short distance and remains quiescent at one side of its mine. During this quiescent period the larval skin remains intact while internally a hypermetamorphic stage is formed, called the intermediate or pseudo-pupal stage. The head of the intermediate stage is formed within that of the mining larva and gradually contracts until the outline of both are readily seen under the microscope. In the meantime the body has gradually become shorter and more cylindrical. The formation of this intermediate stage has been excellently discussed by Rev. J. J. DeGryse (*Proc. Ent. Soc. Wash.*, vol. 18, p. 164, 1916) who observed this phenomenon in *Marmara fulgidella* Clemens.

Within the pseudo-pupal stage is formed the true spinning larva or pre-pupa, and when complete it emerges, casting both the intermediate and mining larval skins at the same time. This is accomplished by forcing its head backward and breaking the skin of both preceding stages transversely at the first abdominal segment. The head and thorax are first liberated, followed immediately by emergence from the abdominal exuviæ.

SPINNING LARVA OR PRE-PUPA (Fig. 24, 2):

Length 5 mm. Color yellowish-brown with tinge of red. Body shorter, more cylindrical, and incisions between segments less pronounced than in mining larva.

Head smaller and more typically lepidopterous than in previous stages (Fig. 24, 6). Chitinous supports reduced in number. Mouthparts markedly different from mining

larval trophi. Labrum (lr) immovably fused with head and bears near its anterior edge six short spines. Mandibles (md) flat, well developed, with median margin serrated, and cross each other similar to the blades of a pair of scissors. In this species their function is still obscure. Maxillæ (mx) present, consisting of three visible segments; a large papilla-like terminal segment bearing laterally a spine near its tip; at the internal distal end of the basal joint are two long bristles which probably correspond to the lacinia of other lepidopterous maxillæ. Labium or spinneret (sp) well developed with labial palpi present. Antennæ similar to those of the mining larva but bear two long bristles on the second joint instead of one as in the mining larva. Ocelli, two pairs with lenses present. On lateral border of head five bristles, three situated near the ocelli and two just anterior to the junction of the head and prothorax. Three more bristles are visible from dorsal view which arise from ventro-lateral margin of head, two near the ocelli and one near the posterior border of the head.

Body. With the exception of the head the body wall of each segment is covered with spine-like processes, like those found on the anterior fourth of each body segment of the larva. From the side of each segment projects a fairly long bristle, with the exception of the first and last two segments which bear two each. A pair of rudimentary legs on each thoracic segment (1, 2 and 3) and a bilobed structure on the ventral side of the last abdominal segment which may function as anal prolegs or may be only a part of the thirteenth segment. No true prolegs of any kind. Last three abdominal segments shrunken and drawn forward.

Formation and Situation of Cocoon.—Heretofore all species of this genus have been described as emerging from the mines and spinning their cocoons in protected crevices, and according to Clemens and Busck, characteristically ornamented by frothy globules.

As mentioned above, the mining larva upon reaching maturity remains quiescent at one side of its mine and gradually becomes more cylindrical during the process of forming the intermediate pseudopupal stage, resulting in an upward pressure upon the epidermal covering of the tunnel which finally splits away from the twig at the opposite side of the mine. In all probability the mining larva weakens the epidermal covering with its mandibles before entering the quiescent stage. As the epidermis breaks away the spinning larva emerges and soon spins a few threads which help cause the cuticle to shrink and form a longitudinal fold under which the white, unornamented silken cocoon is spun (Fig. 24, 7).

Upon completion of the cocoon the spinning larva transforms to the pupa, which occurs during the latter part of June and early July. The spinning larva exuvium is very delicate and shrinks to form a compact ball at the posterior end of the cocoon.

Pupa (Fig. 24, 3):

Length 3.5 mm., width 0.7 mm. Newly formed pupa pale yellow showing a reddish tinge beneath the dorsum of the third, fourth, and fifth abdominal segments, but later becoming brownish with black markings on the wings. Proximal part of the labial palpi not covered by maxillæ. Maxillæ more than half the length of wings and longer than prothoracic legs. A very stout spear-like projection covered with blunt

teeth situated medianly on the front of the head, doubtless enables the pupa to pierce or saw through the cocoon on emergence. Appendages not fused to the body: Metathoracic legs and antennæ equal in length and reach to the last abdominal segment. Two pairs of bristles present on the thorax, one pair laterally on the dorsum of both the meso- and meta-thorax. A smaller, stouter bristle is situated on the lateral sides of the abdominal segments dorsal to each spiracle. Spiracles situated on anterior lateral margins of the abdominal segments project as tuberosities. The anterior fifth of each abdominal segment is banded by spine-like projections similar to those found in the larva and pre-pupa but less distinct. Cremaster absent. Last four abdominal segments movable.

EMERGENCE OF ADULT.—Just previous to the emergence of the adult, the pupa works its way forward, puncturing the cocoon with its spear-like projection and forcing itself half out of the cocoon. In this position the pupa case splits, liberating the tiny moth. This takes place in the vicinity of Amherst, Mass., from the middle to latter part of July. The duration of the pupal stage is at least fourteen days.

ADULT (Fig. 24, 4):

"Labial palpi white, second joint dark fuscous exteriorly; maxillary palpi white on the inner side, fuscous exteriorly. Antennæ white, annulated with brown. Face, head and thorax shining silvery white. Fore wing white with golden-brown and black markings; at the base of the wing is a brown costal spot, on the middle of the wing is a golden-brown transverse fascia, broader on the costal edge than on the dorsal and edged posteriorly by a sharp black, somewhat angulated line; at apical third is an outwardly strongly oblique fascia attenuated towards dorsum and edged posteriorly with black, and a similar fascia also edged with black, but hardly so oblique is situated between this and the tip of the wing. Across the cilia and the extreme tip of the wing is a transverse streak of mixed brown and black. Fore and middle legs with swollen black femora and white tarsi. Hind legs white, shaded externally with brown; tibiæ smooth.

"Alar expanse: 6 to 7 mm."—Busck's description of *Marmara* (*Gracilaria*) *elotella* in *Proc. Ent. Soc. Wash.*, vol. 11, 1909, p. 102.

At the end of this description Mr. Busck states that this species is very close to *Marmara* (*Gracilaria*) *fulgidella* Clemens, and on comparing the two descriptions I find they practically coincide. However, Mr. Busck has made slide mounts of the male genitalia of *M. fulgidella* and *M. elotella* and has found that the two species are abundantly distinct. The fact that *M. fulgidella* mines in the bark of white oak and chestnut, while *M. elotella* mines in apple, coupled with their distinct genitalia proves that these are different species, but, nevertheless, are difficult to separate by descriptions.

As a supplement to the original description of *M. elotella* the following notes are added:

Fore and middle femora black at both ends. Distal end of middle tibia black and bearing two scale-covered spines which are usually black at base and white apically. Tarsi either white or marked with black at the distal end of each segment. From near the base of hind tibia originate two white scale-covered spines, the larger one

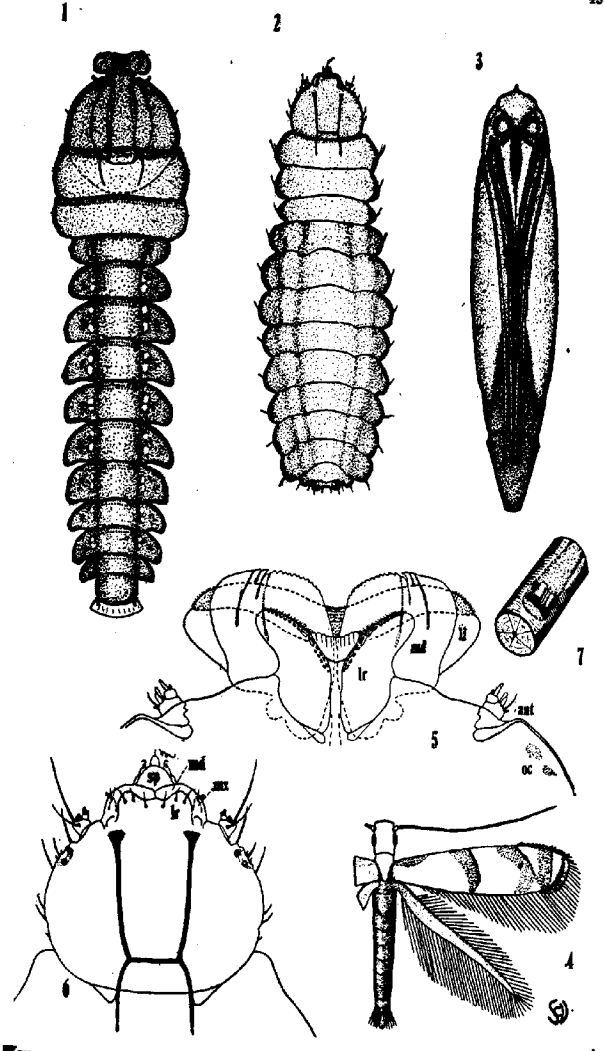


Figure 24. 1, Full grown larva; 2, Spinning larva or pre-pupa, 3, Pupa; 4, Adult. Head, thorax and wing coloration: White, white; Stippled portion, golden-brown; Short black lines, black. 5, Mouthparts of the larva. Labrum (lr); Mandibles (md); Labium (li); Antennæ (ant); Ocelli (oc). 6, Head of spinning larva or pre-pupa. Labrum (lr); Mandibles (md); Maxillæ (mx); Labium or spinneret (sp). 7, Twig showing epidermal fold under which the cocoon is spun.

banded in middle with brown. Two white scale-covered spines arise from the distal end of the hind tibia. Abdomen sometimes wholly white but more generally the anterior fifth of each segment is fuscous.

HABITS OF THE ADULTS.—These tiny moths are very inconspicuous and, like other members of the group, assume a peculiar attitude while at rest. The fore legs are extended while the others are partly folded under the body. In this way the insect rests on the fore legs and the end of the abdomen. The antennæ are held at right angles to the axis of the body and are in constant vibration. During the day these moths are seldom active and remain hidden until dusk, at which time they may be seen flying around their host tree in quite large numbers during early August. In the course of a few days they begin laying eggs for the next generation. Thus it takes a full year for *Marmara elotella* Busck to complete its life cycle.

NATURAL ENEMIES

An undetermined Chalcid parasite is quite efficient in controlling these miners. Many of the larvæ become full grown and spin their cocoons but instead of containing the lepidopterous pupæ, the pupæ of the Chalcid parasite appropriates the comfortable quarters of the sap feeders.

GENERAL CONSIDERATIONS

Although adult characters of *Marmara elotella* correspond to the systematic ideal of the genus, the peculiar method of cocoon formation when taken in comparison to the characteristic Marmaran cocoon, which is ornamented by froth-like globules and has been observed in all species thus far described, shows that one of two things should be done. Either the generic cocoon character must be changed so that it includes the type shown by *M. elotella* or a separate genus should be erected. As stated elsewhere in this paper, I have observed bark miners on pine, ash, and hemlock which form the same characteristic cocoon as *M. elotella*, all of which will probably prove to be different species. Another fact showing difference between this species and other members of the genus may be found in that there are no prolegs in the spinning stage of *M. elotella*, while in other species the prolegs are present.

NEW SPECIES OF ECONOMIC MITES

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In the following paper seven species of mites are described. Six of these species are injurious, some being quite serious pests, and one species is beneficial, being predaceous. Of the seven species described, six are new, and the remaining species, *Tarsonemus pallidus* Banks (?), may prove to be new in the future. This species, which is the one that seriously injures cyclamens, does not agree with Mr. Bank's description of *pallidus*, but probably is the species described by Banks, as specimens agree fairly well with material determined by Banks as *T. pallidus*.

Tetranychus uniunquis n. sp.

A greenish yellow species. Palpi rather stout, reaching the tip of tibia of leg I. Palpal claw rather short, strongly curved and not very sharp at its tip. Thumb of palpus stout, as broad as long, reaching, but not surpassing, the palpal claw; finger of thumb situated in the middle of the apex, about twice as long as broad, and rounded at its tip. Hairs of thumb distributed as follows; two small ones on the inside of thumb near its apex, one long hair, about as long as the thumb itself, on the inside near the base, and another of about equal length on top not far from the base. Cheliceræ each arising near the base of plate, and making an evenly rounded loop posteriorly, and then passing forward for about two-thirds their length, then in a downward direction to their tips. The only place that the cheliceræ are swollen is near their bases. Tarsus of leg I considerably longer than the tibia. Tarsi each ending in a single claw, which is not strongly curved, but is very sharp; two tenent hairs. Length, 0.59 mm.; width, 0.42 mm.

From Urbana, Illinois; on arbor vitae (*Thuja occidentalis*); by the writer.

Tetranychus multidigituli n. sp.

Preserved specimens yellowish. Body somewhat depressed, skin more or less wrinkled, and abdomen somewhat pointed behind. Palpi prominent; claw, strong and much curved; thumb stout, almost as broad as long, and not surpassing the claw; digit or finger about half as long as thumb and less than half as long as brŏad; digituli, or spines, at least five near the tip of thumb, setæ also present on thumb. Mandibles, or cheliceræ, slender, with a simple loop toward base, and of uniform diameter except at base where they are slightly swollen. A single pair of eyes present, placed laterally; cornea strongly curved. Abdomen clothed above with rather stout, simple, slightly curved setæ. Legs moderate; tarsus of leg I about one and a third times as long as tibia, and truncate at its tip, from which springs a very long tactile seta. Tarsal claws rather weak, strongly curved near their bases, beyond which they are divided into six prongs. Onychium with four tenent hairs. Length, 0.30 mm.; width, 0.21 mm.

From Wooster, Ohio; on bark of honey locust, *Gleditsia triacanthos;* by J. S. Houser. Several specimens. This species differs from most of the other species in the genus in having several digituli, or setæ, to

tip of thumb; in having the setæ of the body relatively short and of about the same length, and in having the tip of the tarsi broad and truncate.

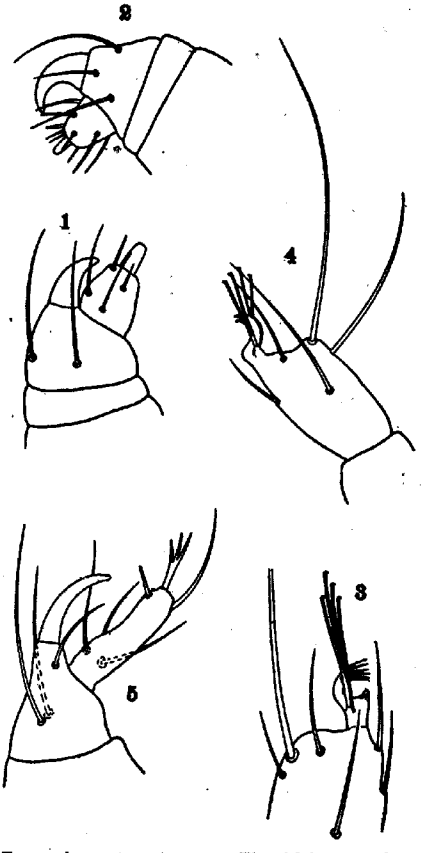

Fig. 25. 1, *Tetranychus uniunguis* n. sp. Tip of left palpus from the inside; 2, *Tetranychus multidigituli* n. sp. Tip of right palpus from the inside; 3, *Tetranychus multidigituli* n. sp. Tip of tarsus showing claw and onychium; 4, *Schizotetranychus latitarsus* n. sp. Tarsus of leg I from the outside; 5, *Caligonus mali* n. sp. Left palpus from the inside.

Schizotetranychus latitarsus n. sp.

Preserved specimens yellowish and reddish with dark spots showing through the body wall. Cephalothorax fully as broad as long. Mandibular plate, or rostrum, over twice as long as broad. Apparently two eyes on each side of cephalothorax,

but only one with a perfect cornea. Palpi prominent; palpal claw very short, stout, and but slightly hooked; thumb swollen, short, not reaching tip of claw, and apparently without digit. Abdomen rather strongly arched, and evenly rounded behind except for the anal papilla. Above, the abdomen is sparsely clothed with long, prominent, slightly curved, minutely pectinate setæ. Legs moderate; tarsus of leg I but slightly longer than tibia, very broad and truncate at its tip; at its tip above it bears a large tactile seta much longer than the tarsus itself. The tarsi of the legs are each provided distally with two subequal, simple claws, and four tenent hairs; of the latter the two inner are longer than the two outer, and all are at least twice as long as the claws. Length, 0.36 mm.; width, 0.23 mm.

From Pasadena, California; on bamboo; by C. P. Clausen. Described from several specimens. This species is probably an introduced one.

Caligonus mali n. sp.

Preserved specimens yellowish and reddish, but live ones brighter with more red. Body oval, about twice as long as broad. Palpi long, reaching about the middle of tarsus I; terminal segment about as long as segment next to it, and ending in a long, downwardly curved, sharp, simple claw. Thumb of palpus cylindrical, slender, surpassing the claw by about one-fourth its length and bearing at its tip a prominent, straight spine, 3-partite at its tip and about one-half as long as the thumb itself, and just below this prominent spine a longer, curved simple seta. Cheliceræ with stout bases, but tapering rapidly toward the slender, sharp, needle-like distal portions. Tips of cheliceræ reach to the distal end of femur of palpus. Abdomen somewhat pointed toward apex, sparsely clothed above with practically straight simple setæ. Legs moderate; anterior pair slightly longer than the others; posterior pair extending for fully one-half their length beyond the tip of the abdomen. Each tarsus is armed distally with two equal claws, between which is a delicate onychium, or pulvillus, composed of a central, longitudinal part from which springs several slender, downwardly projecting seta-like elements. Length, 0.30 mm.; width, 0.16 mm.

From Hillsboro, Oregon; causing a silvering of the leaves of the apple. The apple branches which the writer examined were badly infested and damaged by this mite. Serious injury to apple leaves was reported from Hillsboro, Oregon, in 1913.

Hypoaspis armatus n. sp.

Male.—A uniform, light yellowish-brown color. Body oval, almost evenly rounded behind. Epistome long and ending in two prominent spines or teeth. Cheliceræ very characteristically armed. At the tip of each there is a very prominent lateral, recurved, hook-like projection with a barb at its tip; below this is a sharp incurved hook, which crosses its mate from the opposite side; above is a reduced arm with a pectinate process dorsally and in front. Ventrally near the base of the armed part of the chelicera is a simple tubercle. Peritreme very slender, curved similar to the margin of the body next to which it lies. Abdomen clothed above with a few moderate, slightly pectinate setæ; the shoulder pair is especially prominent. At the anterior end of the abdomen near the median line is a pair of medium, simple setæ. Legs long; tarsus of leg I about one and a half times as long as the tibia and bearing a pair of weak claws at the tip of a very long pedicel; tibia of leg I fully twice as long as broad and broader distally than proximally; last pair of legs extending beyond the tip of abdomen. Length, 0.27 mm.; width, 0.17 mm.

From Whittier, California; on lemon leaves; by Mr. Neüls. The type specimen from Neüls shows the sperm sac attached to the tip of the cheliceræ. In the *Gamasidæ*, the male transfers the sperm from his genital orifice to the vulva of the female in a hyaline sac by means of the cheliceræ. The various modifications of the cheliceræ are frequently adaptations for this method of fertilization.

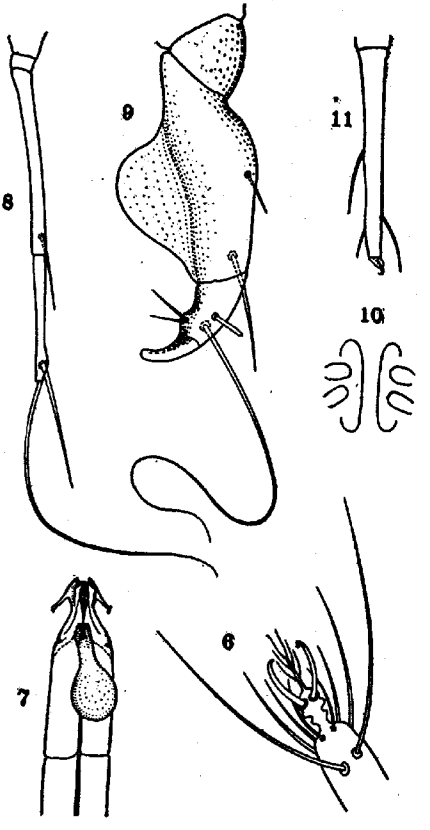

Fig. 26. 6, *Caligonus mali* n. sp. Tip of tarsus of leg I from above; 7, *Hypoaspis armatus* n. sp. Cheliceræ of male from below, showing the sperm sac adhering to the hooks near the tip; 8, *Tarsonemus pallidus* Banks (?) Left hind leg of female from below; 9, *Tarsonemus pallidus* Banks (?) Right hind leg of male, from above; 10, *Monieziella bipunctata* n. sp. Vulva; 11, *Monieziella bipunctata* n. sp. Tarsus of leg IV.

Tarsonemus pallidus Banks (?)

Female.—Body pale yellowish-brown, capitulum darker. Total length of the body about twice that of its greatest width. Capitulum large, extending forward to about the middle of tarsus of leg I. Pseudostigmatic, or sense, organs dorso-lateral, with spherical heads and very short pedicels, which arise from prominent circular pores. Just lateral to each sense organ is situated a very long tactile seta, which surpasses by fully a third of its length leg II, near which it is also situated. Abdomen more or less pointed posteriorly, and bearing along its posterior margin three pairs of small, inconspicuous setæ. Anterior pair of legs stout; second pair slightly smaller; third pair extending beyond the margin of abdomen by the full length of the tarsus and one-half the length of the tibia. Posterior legs reaching the tip of abdomen; tarsus almost two-thirds as long as the tibia, and bearing at its tip a very long terminal seta, as long as the total length of leg IV; a short distance from its tip, on the outside, the tarsus bears a somewhat stouter seta, a little over a third as long as the terminal one. Length, 0.21 mm.; width, 0.12 mm.

Male.—Body stout, legs short. Capitulum reaching the tips of anterior legs. Lateral spine at junction of cephalothorax with abdomen about one-half as long as leg II. Leg IV very characteristic, segment II about two-thirds as long as the entire leg, curved, with a large, hyaline, blade-like expansion on the inside which is almost as broad as the segment proper and extends for about the distal two-thirds of the segment; below near its tip segment II bears a long seta. Segment III of leg IV short, much curved, bearing below near its tip a very long seta, which is equal in length to the entire leg; on the outside there is a short seta, and a more or less spine-like one on the inside at the tip. Distal claw long, curved, but tip not sharpened. Length, 0.13 mm. width, 0.09 mm.

From Corvallis, Oregon; on cyclamen; by G. F. Moznette. Described from several specimens. According to Mr. Moznette this species causes serious injury to the cyclamen plant.

Monieziella bipunctata n. sp.

Alcoholic specimens pale yellowish, with the lateral abdominal maculations a chestnut brown. Cheliceræ large, stout. Cephalothorax more or less triangular in shape; anterior bristles prominent, slightly surpassing the mandibles; posterior bristles equal to about one-half the total length of the body, and each situated about one-half the distance from the median line to the lateral margin of the body. Abdomen separated from the cephalothorax by a transverse almost straight line. Shoulder bristles small, inconspicuous. At its tip the abdomen bears a pair of very long setæ. They are about as long as the width of the abdomen itself. Legs moderate; anterior pair extending beyond the tips of the cheliceræ by about a third of their length. Tarsus of leg I about twice as long as the tibia with a rather stout seta above about one-third the length of the segment from its base, a slender tactile seta above near tip, and a rather long seta ventrally near the base. Length, 0.22 mm.; width, 0.12 mm.

From Oregon; on base of buds of filbert; by A. L. Lovett. Many specimens.

Scientific Notes

Apple and Thorn Skeletonizer (Hemerophila Pariana Clerck). This insect, kindly determined by Karl Heinrich through the courtesy of Doctor Howard, has become well established in Irvington, N. Y., ranging east to White Plains, south to Scarsdale, and is reported as being present for a mile or two on the west bank of the Hudson. The caterpillars skeletonize the upper surface of the leaf, usually drawing in a variable strip on each side about half an inch wide and spinning a light web near the center of the leaf. Portions on each side of the base of the leaves are frequently untouched, though in serious infestations every leaf may be entirely skeletonized and this is true of whole orchards as well as of infested trees. The work of this insect may be distinguished from that of the fall web worm by the absence of the enveloping web inclosing one or more leaves. Furthermore, the full grown caterpillars are only about half an inch long, yellowish, black-spotted, sparsely haired and with the active movements of the Tortricid.

The pest was first brought to our attention by Mr. B. D. Van Buren of the Department of Agriculture and the first American notice was in the *Digest* for the week ending August 16, 1917, issued by the Insect Pest Survey and Information Service of the New York State Food Supply Commission. Subsequent observations show that various sized caterpillars may be found upon the leaves the last of September. It is recorded by Meyrick as local on apple and hawthorn, the moths hibernating and the larvæ being found in May, June and August.

The caterpillars are easily destroyed with poison and, since they feed upon the upper surface of the leaf, it should be impossible for this insect to become abundant in well sprayed orchards.

E. P. Felt.

The Collection of Hemiptera in the United States National Museum. It should be of interest to all American workers in Hemiptera as well as to workers in other orders to know something in regard to what is without doubt the largest collection of Hemiptera in North America. Since the death of the late Otto Heidemann, who was for ten years Custodian of Hemiptera in the United States National Museum, the entire collection has been rearranged.

All specimens are now kept in cork-lined drawers with glass covers, and these in steel cabinets.

The collection of Hemiptera in the Museum includes all of Heteroptera and Homoptera exclusive of Aphididæ, Aleurodidæ and Coccidæ. It has been built up of material sent in from numerous economic workers of the Bureau of Entomology and state departments, by generous donations of specimens from individual workers and students, and also by trades and purchases. The Fitch, Ashmead, Coquillett, and Uhler collections have been notable acquisitions, and it is hoped that in the future the generous spirit which has been the means of building up the best collection of Hemiptera in North America will continue to prompt entomologists to donate specimens freely so that in a short time we may be proud to be able to claim the best in the world.

At the present time there are approximately 150,000 specimens in the collection. Of this 60,000 have been determined. The Nearctic region is represented by 107,000 specimens; the Neotropical by 20,000; the Palæarctic by 10,000; the Ethiopian by 7,000; the Oriental by 3,000; and the Australian by 3,000. The average number of duplicates in a species is 10. There are 600 series of types, cotypes, or paratypes, exclusive of many in the Uhler collection which have never been designated.

Besides the above, the C. F. Baker collection with approximately 30,000 specimens is on deposit and available for study.

During the past six months over 60 series of specimens, many including 25 or more species, from collectors and economic workers, have been determined. This work will be continued zealously and determinations made and returned as quickly as is consistent with accuracy.

EDMUND H. GIBSON,
In Monthly Letter of the Bureau of Entomology.

Notes on Tarsonemus pallidus Banks (Acarina).[1] The pest, *Tarsonemus pallidus* Banks, although common in greenhouses on such plants as geranium, cyclamen, snap-dragon, etc., has not been studied sufficiently to afford life-history data upon which to base control measures.

The mite lays eggs on the under surface of the leaves either singly or in groups. The eggs hatch in 3 to 7 days at a temperature of 25°C. and the larva which is minute and pearly white passes through two stages, an active and a quiescent period. The active period averages 2.2 days and the quiescent, 1.7 days, the temperature ranging between 20 and 25°C. The skin is moulted at the end of the quiescent period and the adult mite emerges. The total length of the life cycle from egg to adult averages 9.1 days. The adults begin to lay within two days after emergence and the eggs whether fertilized or not produce normal larvæ usually of the female sex. The insect is parthenogenetic and continuous generations of isolated females have been kept for 5 months without the intervention of the male. The eggs are laid at the rate of 1 or 2 per day and adults kept in confinement sometimes live as long as 17 days. The total egg-laying capacity is from 12 to 17 eggs per female. Fertilization apparently takes place while the female is still quiescent, but copulation has also been seen to take place between adults of both sexes. The ratio of males to females under normal conditions is about 1 to 8.

Experiments indicate that in winter little trouble should be experienced from the attacks of the mite if plants are kept well spaced and reasonably dry. In summer it is best to syringe daily until control is obtained with a stream of not less than fifty pounds pressure. The mites are more easily dislodged than the red-spider and control methods offered for the latter mite by Ewing[2] are therefore effective in combating the Tarsonemus mite.

The writer suggests the name "pallid mite"[3] as a common name rather than "cyclamen mite" as used by Moznette,[4] because of the fact that it occurs on other plants as well as cyclamen and often causes as much or more injury than to cyclamen.

PHILIP GARMAN.

The Reddish-brown Plum Aphis in New York State. In reference to the paper by W. M. Davidson on p. 350, vol. 10, of the JOURNAL, the following information may be of interest. In 1897, Lintner, 13th Rept., p. 363, recorded the presence of a species infesting the plum. Specimens were sent to Washington and were studied by Mr. Pergande, but were not determined specifically. Pergande's note is as follows: "June 21, 1897. Received from J. A. Lintner, Albany, N. Y., a few specimens of a *Rhopalosiphum* found at East Greenbush, Rensselaer Co., opposite Albany, on a

[1] Contribution from the Entomological Department, Maryland Agricultural Experiment Station.

[2] Ewing, H. E. Oregon Agr. College Exp. Station. Bul. 121: 87, 1914.

[3] Garman, P. Maryland Agr. Exp. Station. Bul. 208, 1917.

[4] Moznette, G. F. JOUR. ECON. ENT. 10: 344, 1917.

plum tree, infesting largely the fruit." A short color description then follows. These specimens are in the collection of the Bureau of Entomology and prove to be spring migrants of *nymphæ*. This is possibly the earliest American record of the plum-feeding habit of the species.

The foregoing information was submitted to Mr. Davidson, but he preferred to confine his remarks to western material.

Recently we have received specimens from Mr. W. F. Turner, Thomasville, Ga., which add another state to the distribution records.

A. C. BAKER, *Washington, D. C.*

Scientific Note on Beetles Causing Damage to Cotton in Yuma Valley, Arizona. In answer to a communication from Dr. A. W. Morrill the writer visited fields in the Yuma Valley of Arizona where severe injury to seedling cotton was reported. Interviews with leading planters and examination of affected fields brought to light the fact that about 500 acres had been replanted twice following as many complete destructions of the seedling fields. The attempts to secure a stand were finally abandoned, and milo was planted. Careful examinations in these fields revealed the presence in millions of a dirt-colored beetle $^{2}/_{16}$-inch long, which has been determined by Mr. E. A. Schwarz as *Myochrous longulus* Lec.

In the affected fields not a trace of cotton was to be seen above ground. Search in the soil of the bed rows revealed the presence in great numbers of the above species. The adults were seen in many cases still in place on the underground portion of the stems of the decapitated seedlings, but were also seen commonly feeding on the subterranean, succulent stems of arrowweed, trailing-mallow and *Baccharis* sp.

All affected fields were in crop for the first time, and, prior to clearing, the land had (last season) supported an almost pure growth of arrowweed (*Pluchea sericea*). Owing to the ease with which the Myochrous beetles were found on the arrowweed stems it would appear probable that this is the native host of the pest. It is reasonable to suppose, then, that following the eradication of the arrowweed the beetles transferred their attentions to the young, tender cotton plants which were readily at hand.

E. A. MCGREGOR.

A Second Importation of the European Egg-Parasite of the Elm Leaf-Beetle. In the JOURNAL of ECONOMIC ENTOMOLOGY, vol. I, No. 5, 1908, pages 281–289, I gave an account of the importation of *Tetrastichus xanthomelænæ* into this country through the help of the late Professor Valery Mayet, of Montpellier, France, and of its apparent establishment in The Harvard Yard and at Melrose Highlands, Massachusetts, and of its attempted colonization by the late Dr. John B. Smith at New Brunswick and the late M. V. Slingerland of Ithaca and upon elm trees in Washington near Dupont Circle. Since the publication of this article, this species has not been recovered in the United States. The death of Professor Valery Mayet and the scarcity of the elm leaf-beetle in the south of France for several years, and later the oncoming of the great war, have prevented other attempts to introduce and establish this active parasite.

On the 25th of June of the present year, however, I received from Prof. F. Picard, of the École Nationale d'Agriculture, Montpellier, a cigar-box full of elm leaves bearing parasitized eggs of *Galerucella luteola*. I turned the material over to Mr. J. Kotinsky of the Bureau of Entomology, and telegraphed to Prof. J. G. Sanders, Dr. T. J. Headlee, and to the Entomological Department of Cornell University for information as to the prospects of colonization. The season was already late, and the para-

sites were coming out on arrival. Moreover, the box was not tight. On the day following the arrival of the sending, Mr. Kotinsky brought together thirty adults which were active and mated freely. Elm leaves daubed with honey were supplied to them for nourishment, but they gave little attention to it. No elm leaf-beetles were found in Washington, and Mr. Kotinsky, on receipt of a telegram from Mr. Sanders to try Philadelphia, bottled the colony and took it to that city. With Mr. F. M. Trimble, one of Mr. Sanders' assistants, a search for the elm leaf-beetle was first made in Logan Square opposite the Philadelphia Academy of Natural Sciences, where they were accompanied by Dr. Henry Skinner, and later in Fairmont Park, but to no avail. Finally eggs of the elm leaf-beetle were located near the Andorra Nurseries, City Line, Chestnut Hill, Philadelphia, and most of the parasites were released on the south side of Barren Hill Road, middle tree (eighth from either end), between the first and second road entrances to the nursery grounds. Eggs confined with the insects in a vial prior to their release did not seem to attract them.

In the meantime, Prof. Robert Matheson, of Cornell, had notified the writer that some eggs were still unhatched at Ithaca, and, on orders from the Washington office Mr. Kotinsky mailed the remaining parasites to Ithaca.

On Mr. Kotinsky's return to Washington, a few more parasites were found to have issued, and eventually these were released, on the 19th of July, on an elm tree in the back yard of 1914 Sixteenth Street, where fresh elm leaf-beetle eggs were found.

Professor Picard promises another sending in 1918, and the writer will be glad if entomologists interested will notify him of their wish to attempt the colonization in regions of elm leaf-beetle abundance next June.

L. O. HOWARD.

THIRTIETH ANNUAL MEETING, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, PITTSBURGH, PA., DECEMBER 31, 1917 TO JANUARY 2, 1918.

The Thirtieth annual meeting of this Association will be held at Pittsburgh, Pa., on the dates above mentioned. Sessions will also be held for the section on Apiculture and the section on Horticultural Inspection.

The exact hours of holding the sessions of this Association and its sections, together with the program, will be published in the December number of the JOURNAL OF ECONOMIC ENTOMOLOGY. It is planned to devote one session to a symposium on some important phase of insect investigations.

In order for papers to be included in the program, it will be necessary for the titles to be filed with the Secretary on or before *November 10*. Papers should be prepared so that they can be presented in not to exceed fifteen minutes; and it is suggested that if the subject which is covered will require a longer time, that an abstract be read.

Titles of papers to be presented before the section on Apiculture should be forwarded to the Secretary of that section, Mr. N. E. Shaw, Secretary of Agriculture, Columbus, Ohio. Titles on Horticultural Inspection should be forwarded to the section on Horticultural Inspection, Prof. J. G. Sanders, Economic Zoölogist, Harrisburg, Pa.

Entomologists desiring to become members of the Association can secure the necessary blanks from the Secretary or from Prof. J. G. Sanders, Harrisburg, Pa., who is the Chairman of the membership committee.

PROF. R. A. COOLEY, *President*,
Bozeman, Mont.

A. F. BURGESS, *Secretary*,
Melrose Highlands, Mass.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

OCTOBER, 1917

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photoengraving may be obtained by authors at cost. The receipt of all papers will be acknowledged.—Eds.

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Crop production and food conservation have received much attention this season and will be given more another year. The large appropriations ($145,775 allotted to the Bureau of Entomology) just made for this work by the federal government are none too great for the country as a whole, especially when we remember that it is impossible to wage a successful contest on an inadequate food supply. The practical side of entomology never has had a better chance to demonstrate its utility and more will be demanded along this line another year. It should not be forgotten that we are dealing with living organisms and while prognosis is possible to some extent, much can not be foreseen. The organization which wins will be a flexible one, planned upon comprehensive lines and adapted to rapid changes. The probable should be anticipated, the improbable guarded against and the work at all times be upon a practical basis.

The above considerations compel the limiting of major activities to the control of the more important pests along lines of demonstrated utility. The shortage of help is favorable to the increased use of machinery and it is quite possible that in some localities wholesale spraying on a scale hitherto considered impractical would be entirely feasible. The problem is to secure the greatest possible protection from insect depredations with a minimum expenditure of effort. This suggests the practicability of high power spraying outfits manned by trained crews in sections where there is great need for spraying. Insecticides are of little value without spraying machinery. The next

few months should be devoted to learning the needs for both and making plans to secure the effective distribution of machinery and insecticides. One is well nigh useless without the other. This distribution must be followed by effective operation or the work counts for little.

Data at hand should be made available to indicate the safest rotations or desirable modifications in cropping in order to prevent insect injury. Every entomologist knows the risk incurred by planting corn or potatoes on land badly infested by young white grubs, the sowing of wheat early enough to permit infestation by Hessian fly, etc. Such precautions involve little or no additional labor. Self-interest, if not concern for the national welfare, should and probably will lead most farmers to observe these common-sense precautions and it is for the economic entomologist to see that he can not plead ignorance of the matter—it would be even better if growers had the stimulus of nearby demonstrations.

Reviews

School Entomology, An Elementary Textbook of Entomology for Secondary Schools and Agricultural Short Courses, by E. DWIGHT SANDERSON and L. M. PEAIRS. John Wiley & Sons, New York, 1917. Pp. 356, figs. 233. Price, $1.50.

We have in this work an excellent discussion of the systematic and economic phases of entomology admirably adapted to the needs of agricultural and secondary students in particular. There is enough of structure and taxonomy to give the student a good idea of insect life and yet this aspect is not allowed to obscure the more practical part II. It has been said, and truly, that all entomology is economic and yet there are some works on economic entomology that run largely to the systematic and vice versa. This book is admirably proportioned. The keys are sufficient for considerable taxonomic work. The student will find material assistance in the series of illustrations showing types of the more important groups of insects. The economic part is limited to discussions of the more destructive pests. The value of the book is greatly increased by the short list of the more important recent contributions to insect literature, thus making further study easy. The authors have produced a very meritorious work which will be greatly appreciated by teachers and students. (*Adm.*)

Current Notes

Conducted by the Associate Editor

Mr. S. B. Doten is secretary of the Nevada State Committee on Food Resources.

Mr. A. O. Larson, B. S., has been appointed assistant entomologist at the Utah Station.

Mr. W. A. Keleher, for many years a valued employee of the Bureau of Entomology, died early in August.

Mr. Frank H. Lathrop has been appointed research assistant in entomology at the Oregon College and Station.

Mr. H. R. Hagan has been appointed assistant professor of zoölogy and entomology at the Utah College and Station.

Mr. F. M. Wadley, Bureau of Entomology, will be in charge of the Field Station at Wichita, Kans., vice F. B. Milliken.

Dr. J. Chester Bradley of Cornell University will spend next year as assistant professor of entomology at the University of California.

Mr. A. P. Sturtevant, Bureau of Entomology, recently made a trip in New Jersey and Massachusetts studying European foulbrood conditions.

Mr. H. L. Weatherby, Bureau of Entomology, will be in temporary charge of the station at Rocky Ford, Colo., formerly in charge of Mr. Marsh.

Dr. E. F. Phillips, Bureau of Entomology, went to Denver, Colo., the last of July to attend a meeting of beekeepers of Colorado and adjacent states.

Mr. August Busck, Bureau of Entomology, left Washington on August 20 for an extended trip through northern Mexico, to study the pink bollworm.

Professor H. A. Morgan, director of the Agricultural Experiment Station, Knoxville, Tenn., has recently been appointed Federal food administrator for the State of Tennessee.

Mr. H. E. Shaw, formerly Chief of the Bureau of Horticulture, Ohio State Department of Agriculture, has recently been appointed Secretary of Agriculture for the State of Ohio.

Mr. J. S. Houser, Associate Entomologist of the Ohio Station, served for two or three months as District Food Commissioner of two Ohio counties, returning to his work at the Station July 1.

Mr. Morley Pettit, of the Ontario Agricultural College, Guelph, has resigned as Provincial Apiarist, and after November 1, 1917, will devote his attention to The Pettit Apiaries, with headquarters at Georgetown, Ont.

Mr. George F. Moznette, assistant in entomology at the Oregon College and Station, has resigned to accept a position as entomological inspector of the Federal Horticultural Board and assigned to duty at Washington, D. C.

Dr. D. W. Pierce, Bureau of Entomology, made a general trip in July through the South, visiting the laboratories at Madison, Fl., Mound, La., Clarksville, Tenn., Dallas, Texas, Uvalde, Texas, and El Centro, Calif.

Mr. F. E. Brooks, Bureau of Entomology, in charge of the laboratory at French Creek, W. Va., visited Michigan and Wisconsin during the latter part of June in connection with his studies of apple-tree and other borers.

Mr. D. M. Rogers, in charge of gipsy moth quarantine and inspection work, Bureau of Entomology, has moved his office from No. 43 Tremont Street, Boston, Mass., to the Boston Custom House, effective September 1, 1917.

Messrs. T. L. Guyton, J. R. Stear and P. R. Lowry, all entomological students from the Ohio State University, were employed during the summer months by the entomological department of the Ohio Station at Wooster.

Mr. G. S. DeMuth, Bureau of Entomology, went to Blacksburg, Va., August 16 to attend a meeting of beekeepers held at that place during Farmers' Week. At this meeting the Virginia State Beekeepers' Association was organized.

During July and August Mr. V. L. Wildermuth, Bureau of Entomology, made an extended insect survey through the northern part of Arizona, being accompanied, for a portion of the time, by Dr. O. C. Bartlett, Assistant State Entomologist.

A bill will probably be considered by the Texas legislature now in special session providing for the establishment of a cotton-free zone to include the counties bordering on Mexico, such zone to be administered in coöperation with the Federal Horticultural Board.

Mr. Kenneth Hawkins, Bureau of Entomology, left Washington July 9 to attend state meetings of county agents in Oklahoma, Texas and other Southern States, and spent the latter part of August in Virginia, holding local meetings of beekeepers in coöperation with county agents.

Dr. D. W. Pierce, Bureau of Entomology, finds several species of European origin among our *Gymnætron* and *Miarus* and therefore desires to receive for study material from all parts of the country. *Gymnætron* breeds in the flowers of *Verbascum* and *Linaria*, and *Miarus* breeds in the flowers of *Lobelia*.

Recent visitors to the Bureau of Entomology include Professor K. W. Dammermann, Java; Professor H. Garman, Lexington, Ky.; Professors E. R. Scholl, F. B. Paddock, S. W. Bilsing, entomologists, and Mr. E. L. Ayers, Chief Nursery Inspector, Texas; H. G. Barber, Roselle Park, N. J.; Carl J. Drake, Syracuse, N. Y.

Mr. R. D. Whitmarsh, assistant entomologist of the Ohio Station, served as military instructor at the University of Wooster during the spring months, devoting four afternoons each week to this instruction. Mr. Whitmarsh has volunteered for the Second Officers' Training Camp at Fort Benjamin Harrison at Indianapolis, Ind.

Mr. Simon Marcovitch, assistant entomologist for the past three years at the University of Minnesota, has resigned his position to accept an offer as head of the Department of Biology at the National Farm School, Bucks County, Pennsylvania. Mr. Marcovitch expected to leave September 14 to take up his new duties in the East.

The following resignations from the Bureau of Entomology have been announced: Miss Myrtle Duckett, Bee Culture; B. L. Royden, Truck Crop Insect Investigations;

Pauline Margaret Johnson, Truck Crop Insect Investigations; F. H. Gates, Cereal and Forage Insect Investigations; H. L. Parker, Cereal and Forage Insect Investigations.

Dr. William M. Wheeler, of Harvard University, Dr. J. Chester Bradley of Cornell University, and Dr. C. L. Bequaert of the American Museum of Natural History, New York City, spent about a week in the vicinity of Tempe, Arizona, collecting insect material and were frequent visitors at the field laboratory maintained there by the Bureau of Entomology.

Mr. T. E. Snyder, Bureau of Entomology, returned to Washington on July 31 from a trip through the Southern, southwestern Pacific Coast and Rocky Mountain States. On this trip insects injurious to forest products were investigated. Special effort was made to collect termites and data on the biology and geographical distribution of our native species. Mr. Snyder left Washington on March 16.

During June and the early part of July, Dr. E. A. Back, Bureau of Entomology, made an extended trip through the Middle West and the South to familiarise himself with the methods of storing grain and with insects affecting warehouses, grain elevators and flour mills. The establishments of many large concerns were visited in Chicago, Minneapolis, Kansas City, Wichita, Galveston, New Orleans, and elsewhere.

Dr. C. H. T. Townsend, Bureau of Entomology, is on an extended trip in the southwest to determine the exact range of the *Thurberia* plant and the weevil which feeds upon it. Special attention will be paid to the possible occurrence of the plant and weevil in regions in which cotton is now planted or in which it may be planted some time in the future. Dr. Townsend started from Las Cruces in New Mexico early in July with a pack train and will explore the country as far as Globe, Ariz., before the end of the season.

F. C. Bishopp and E. W. Laake, Bureau of Entomology, have completed a general trip of inspection to the larger meat packing establishments in the United States. This work is in coöperation with the Bureau of Animal Industry and has relation to the control of the house-fly and other insects in establishments operating under federal supervision. Later Mr. Bishopp made a trip to the Pacific Northwest, returning to Dallas via Topaz, California, where Mr. Webb is engaged in the study of insects affecting the health of animals.

An insect menace of considerable interest to citrus growers, particularly those of Florida, is the spiny citrus "white fly," *Aleurocanthus woglumi*. This insect, probably originating in India, has obtained a strong foothold in Cuba during the last few years, and may easily reach Florida by means of fruits or plants imported from Cuba. Harold Morrison, who is now in Cuba, is making a thorough investigation of this insect in Cuba and adjacent islands to provide adequate information for necessary quarantine or regulatory action.

The following employees of the Bureau of Entomology and the Federal Horticultural Board are variously designated for the military and naval service of the government: John Monteith, Jr., H. L. Parker, G. D. Pylant, T. S. Wilson, P. B. Miles, B. R. Leech, F. P. Keen, A. C. Mason, R. L. Daily, T. R. Chamberlain, D. J. Caffrey, H. K. Laramore, J. J. Culver, G. N. Wolcott, G. W. Martin, Harry D. Whitlock, L. J. Hogg, Manuel Garcia, L. P. Rockwood, Frank R. Cole, E. J. Newcomer, J. C. Evendon, W. E. Dove, H. B. Greaves, C. F. Cork and R. H. Bush.

According to the *Experiment Station Record*, the staff of the Department of Entomology at the Kansas College and Station and Federal entomologists are being organized to control the Hessian fly in counties where it promises to injure the wheat crop in 1918. The early and thorough plowing under of wheat stubble, elimination of volunteer wheat in fields later, and planting after the fly-free date are the recommendations being made. These practices, however, are advisable in order to obtain maximum yields, regardless of Hessian fly infestation.

Mr. Harold Morrison, Bureau of Entomology, who recently made a trip of exploration to the Virgin Islands and the West Indies, has completed his work in the Virgin Islands and Porto Rico and is probably now in Santo Domingo. Some very interesting communications have been received from him in relation to this work and good deal of valuable material. Valuable material is also being received from the collaborators appointed in Central and South American countries in connection with the study of the fruit-flies and other insect pests of such countries.

Mr. Jacob Kotinsky, Bureau of Entomology, spent June 27 in Philadelphia where, with the assistance of F. M. Trimble of the Pennsylvania State Zoölogical Service and the Federal Horticultural Board, elm-leaf beetle, *Galerucella luteola* Mull., eggs were located and a colony of parasites received by Dr. Howard from M. F. Picard of the École Nationale d'Agriculture, Montpelier, France, was released. Small colonies of this parasite were also released in Ithaca, N. Y., by Professor Robert Matheson and by Mr. Kotinsky in Washington, D. C. No prediction as to results can be made as yet.

Mr. H. F. Dietz, Bureau of Entomology, is now in New York investigating the fumigation of orchids. The experimental work conducted by Messrs. Sasscer and Dietz with orchids has demonstrated that orchids can be safely fumigated with one ounce of sodium cyanid in a 20-inch vacuum at an exposure of 40 minutes without injury, provided reasonably healthy plants are used; in fact, with healthy plants as strong a dose as four ounces of cyanid has been used under the same conditions without killing the plants. A month after treatment the plants so treated are making new growth, both roots and buds.

C. W. Howard, Associate Professor of Entomology and Parasitology, University of Minnesota, has accepted the position of Professor of Biology in Canton Christian College, Canton, China. Professor Howard will sail from San Francisco the middle of October, visiting the Hawaiian Islands, Manila and Japan enroute. Canton Christian College is the only institution of collegiate rank in South China. The rapid growth of the agricultural and medical departments has made necessary the organization of a department of biology. All communications should be addressed to Canton Christian College, Honglok, Canton, China.

The following transfers in the Bureau of Entomology have recently been announced: W. T. Emery, Charlottesville, Va., to Wellington, Kans.; G. A. Runner to Sandusky, Ohio; J. S. Wade, Wellington, Kans., to Washington, D. C.; Dwight Isely, North East, Pa., to Bentonville, Ark.; J. J. Culver, Fort Valley, Ga., to Monticello, Fla.; A. I. Fabis, Monticello, Fla., to Brownwood, Tex.; D. J. Caffrey, Tempe, Ariz., to Hagerstown, Md., in charge of the laboratory; J. A. Hyslop, formerly in charge of the Hagerstown, Md., field laboratory, to Bureau Extension work; G. W. Barber, Wellington, Kans., to Hagerstown, Md.; H. O. Marsh, Rocky Ford, Colo., to New Jersey (temporarily); F. B. Milliken and A. B. Duckett, formerly truck crop insect investigations, to stored product insect investigations.

An estimate has been prepared for the Urgent Deficiency Bill of this session, calling for an appropriation of $500,000 to still further safeguard the United States from the pink bollworm. A conference was held on July 17 on this work, participated in by representatives appointed by the Governor of Texas, namely, the Commissioner of Agriculture and Messrs. Ayers and Scholl, and by Mr. Paddock, representing the experiment station, and Mr. Ousley, temporarily acting as Assistant to the Secretary of Agriculture, representing the state at large and particularly the State Extension Service. There was also present a committee of planters, representing the Lower Rio Grande Valley. The work proposed under the appropriation requested is the establishment of a cotton-free zone in Texas along the Mexican border, the survey and stamping out of local points of infestation in Mexico near the Texas border, and general surveys of the infested district in the Laguna and elsewhere in Mexico to be the basis of determining the advisability of undertaking exterminative work against the pink bollworm in Mexico generally.

The following appointments to the Bureau of Entomology have been made recently: Robert B. McKeown, a graduate of the Colorado Agricultural College assigned to deciduous fruit insect investigations to be located in Texas; Warren D. Whitcomb, a graduate of the Massachusetts Agricultural College, deciduous fruit insect investigations, Northern States; William O. Ellis, Syracuse University, deciduous fruit insect investigations, Riverton, N. J.; Chester I. Bliss, field assistant, deciduous fruit insect investigations, Sandusky, Ohio; F. S. Chamberlin, southern field crop insect investigations, Quincy, Fla.; G. D. Pylant, southern field crop insect investigations, Madison, Fla.; George E. Quinter, southern field crop insect investigations, Clarksville, Tenn.; J. W. Bailey, cereal and forage insect investigations, Tempe, Ariz.; P. H. Hertzog, cereal and forage insect investigations, Carlisle, Pa.; Frederick W. Poos, cereal and forage insect investigations, Charlottesville, Va.; W. C. Cartwright, cereal and forage insect investigations, Knoxville, Tenn.; H. L. Dozier, a graduate of the University of South Carolina, cereal and forage insect investigations, Tempe, Ariz.; H. R. Shoemaker, truck crop insect investigations, Arlington, Va.

Zoölogical Record: a correction. In the May 1917 *Monthly Letter* of the Bureau of Entomology a note appeared saying the *Zoölogical Record*, London, had temporarily suspended publication. This word was received by the Smithsonian Institution through its London agents. We are glad to learn now through a letter to Dr. Howard, under date of May 21, from Mr. P. Chalmers Mitchell, Secretary of the Zoölogical Society of London, that this is a mistake. The 1915 volume of the *Record* will appear soon and the 1916 volume is in preparation. The Society has no intention of letting the *Record* be suspended.

MABEL COLCORD,
Librarian, Bureau of Entomology.

Mailed October 20, 1917.